A.2 RFI PHASE II SOIL/FILL SAMPLE RESULTS

DATE: 01/18/94
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ANALYTICAL REPORT

EPA NUMBER: SDG NUMBER: LAB ID: DATE RECEIVED: DATE ANALYZED:	S011308 SOIL P245155 08/10/93 08/17/93	S011704 SOIL P245156 08/12/93 08/17/93	S011710 SOIL P245157 08/12/93 08/17/93	S011904 SOIL P245276 08/16/93 08/24/93	S012213 SOIL P247080 09/02/93 09/10/93
Units: ug/kg					
chloromethane [methyl chloride]	1400.000 U	1300u ~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
bromomethane [methyl bromide]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
vinyl chloride	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
chloroethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
dichloromethane [methylene chloride]	1400.000 U	~~1300.000 DJ~~	2100000.000 U J	5500.000 U	27000.000 U
acetone	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
carbon disulfide	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,1-dichloroethene [1,1-dichloroethylene]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U J	27000.000 U
1,1-dichloroethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,2-dichloroethene (total)	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
chloroform	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,2-dichloroethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
2-butanone [methylethyl ketone] [MEK]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,1,1-trichloroethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
carbon tetrachloride	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
bromodichloromethane [dichlorobromomethane]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,2-dichloropropane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
cis-1,3-dichloropropene	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
trichloroethene [trichloroethylene]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
dibromochloromethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
1,1,2-trichloroethane	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
benzene	1400.000 U	27000.000 ~~D~~	16000000.000	4200.000 J	27000.000 U
trans-1,3-dichloropropene	1400.000 U	1300u ~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
tribromomethane [bromoform]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
4-methyl-2-pentanone [methyl isobutyl ketone] [MIBK]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 UJ
2-hexanone	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
tetrachloroethene [tetrachloroethylene]	1400.000 U	~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 UJ
methylbenzene [toluene]	1400.000 U	51000.000 ~~D~~	14000000.000	59000.000	28000.000
1,1,2,2-tetrachloroethane	1400.000 U	1300u ~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
chlorobenzene	1400.000 U	1300u ~~2700.000 U~~	2100000.000 U	5500.000 U	27000.000 U
ethylbenzene	1400.000 J	~~7600.000 D~~	2100000.000 U	13000.000	98000.000
styrene	1400.000 U	1300u ~~2700.000 U~~	2100000.000 U	20000.000	27000.000 U
xylenes	3500.000	46000.000 ~~D~~	2100000.000 U	140000.000	310000.000
cumene	ND	ND	ND	ND	ND
alpha methyl styrene	ND	ND	ND	ND	ND

ND - Not Detected.

MLA
1/25/94

Halliburton NUS CORPORATION

NUS LABORATORY
Two Marquis Office Plaza, Suite 200
5313 Campbells Run Road
Pittsburgh, Pennsylvania 15205

(412) 747-2580
FAX: (412) 747-2684

October 28, 1993
Report No.: 00017651

LABORATORY ANALYSIS REPORT

CLIENT NAME: ALLIED FIBERS - C/O HALLIBURTON NUS CORPORATION
ADDRESS: 993 OLD EAGLE SCHOOL ROAD, STE 4
WAYNE, PA 19087-1970
ATTENTION: PAUL PERSING

NUS CLIENT NO: 1508 0004
WORK ORDER NO: 0091
VENDOR NO:

Carbon Copy:

SAMPLE ID: MW112-01
NUS SAMPLE NO: P0250070
P.O. NO.:

DATE SAMPLED: 05-OCT-93
DATE RECEIVED: 06-OCT-93
APPROVED BY: Kieda, Chuck

LN.	TEST CODE	DETERMINATION	RESULT	UNITS
5	ACLPW	TAL METALS & CLP DATA PACKAGE	DONE	
6	I106	Carbon, Organic - Nonpurgeable	4	mg/L
7	I050	BOD (O2) - 5 day	12	mg/L
8	I320	Hardness, Total (as CaCO3)	120	mg/L
9	I023	Alkalinity, Total (as CaCO3)	89	mg/L
10	I590	Solids, Dissolved at 180C	210	mg/L
11	OVTWC	TCL - VOA + CLP DATA PACKAGE - WATER		
		Data Package - VOA	DONE	
12	OSTWC	TCL - BNA + CLP DATA PACKAGE - WATER		
		Data Package - BNA	DONE	

COMMENTS:

Halliburton NUS
CORPORATION

NUS LABORATORY
Two Marquis Office Plaza, Suite 200
5313 Campbells Run Road
Pittsburgh, Pennsylvania 15205

(412) 747-2580
FAX: (412) 747-2684

November 01, 1993
Report No.: 00017708
Section A Page 1

LABORATORY ANALYSIS REPORT

CLIENT NAME: ALLIED FIBERS - C/O HALLIBURTON NUS CORPORATION
ADDRESS: 993 OLD EAGLE SCHOOL ROAD, STE 4
WAYNE, PA 19087-1970
ATTENTION: PAUL PERSING

NUS CLIENT NO: 1508 0004
WORK ORDER NO: 0091
VENDOR NO:

Carbon Copy:

SAMPLE ID: MW113-01
NUS SAMPLE NO: P0250764
P.O. NO.:

DATE SAMPLED: 11-OCT-93
DATE RECEIVED: 12-OCT-93
APPROVED BY: Kieda, Chuck

LN	TEST CODE	DETERMINATION	RESULT	UNIT
5	ACLPW	TAL METALS & CLP DATA PACKAGE	DONE	
6	I106	Carbon, Organic - Nonpurgeable	24	mg/L
7	I050	BOD (O2) - 5 day	< 20	mg/L
8	I320	Hardness, Total (as CaCO3)	320	mg/L
9	I023	Alkalinity, Total (as CaCO3)	400	mg/L
10	I590	Solids, Dissolved at 180C	450	mg/L
11	OVTWC	TCL - VOA + CLP DATA PACKAGE - WATER		
		Data Package - VOA	DONE	
12	OSTWC	TCL - BNA + CLP DATA PACKAGE - WATER		
		Data Package - BNA	DONE	

COMMENTS:

ANALYTICAL REPORT

EPA NUMBER:	S011308	S011704	S011710	S011904	S012213
SDG NUMBER:	SOIL	SOIL	SOIL	SOIL	SOIL
LAB ID:	P245155	P245156	P245157	P245276	P247080
DATE RECEIVED:	08/10/93	08/12/93	08/12/93	08/16/93	09/02/93
DATE ANALYZED:	8/20/93	8/20/93	8/20/93	8/20/93	9/11/93
Units: ug/Kg					
phenol	12000.000 U	110000U ~~1100000.000~~ U	28000.000 U	24000.000 J	890000 U ~~180000000.~~
bis(2-chloroethyl)ether	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2-chlorophenol	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
1,3-dichlorobenzene [m-dichlorobenzene]	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
1,4-dichlorobenzene [p-dichlorobenzene]	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
1,2-dichlorobenzene [o-dichlorobenzene]	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2-methylphenol [o-cresol]	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
bis(2-chloroisopropyl)ether	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
4-methylphenol [p-cresol]	12000.000 U	~~1100000.000~~ U	28000.000 U	17000.000 J	~~180000000.~~
N-nitrosodi-n-propylamine	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
hexachloroethane	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
nitrobenzene	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
isophorone	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2-nitrophenol	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2,4-dimethylphenol	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	930000 ~~180000000.~~
bis(2-chloroethoxy)methane	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	890000U ~~180000000.~~
2,4-dichlorophenol	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
1,2,4-trichlorobenzene	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
naphthalene	69000.000	5500000.000 [illegible]	81000.000	320000.000	630000000.
4-chloroaniline	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
hexachlorobutadiene	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
4-chloro-3-methylphenol [p-chloro-m-cresol]	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2-methylnaphthalene	19000.000	1200000.000 [illegible]	16000.000 J	42000.000 J	1700000 J ~~180000000.~~
hexachlorocyclopentadiene	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
2,4,6-trichlorophenol	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
2,4,5-trichlorophenol	29000.000 U	280000 U ~~2800000.000~~ U	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
2-chloronaphthalene	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
2-nitroaniline	29000.000 U	280000 U ~~2800000.000~~ U	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
dimethyl phthalate	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
acenaphthylene	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	170000 J ~~180000000.~~
2,6-dinitrotoluene	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
3-nitroaniline	29000.000 U	280000 U ~~2800000.000~~ U	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
acenaphthene	49000.000	340000 ~~350000.000 DJ~~	28000.000 U	57000.000 U	1900000 ~~180000000.~~
2,4-dinitrophenol	29000.000 U	280000 U ~~2800000.000 U~~	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
4-nitrophenol	29000.000 U	~~2800000.000 U~~	69000.000 U	140000.000 U	~~440000000.~~
dibenzofuran	39000.000	450000.000 ~~DJ~~	28000.000 U	57000.000 U	1900000 ~~180000000.~~
2,4-dinitrotoluene	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
diethyl phthalate	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
4-chlorophenyl phenyl ether	12000.000 U	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~

MLA
1/25/94

ANALYTICAL REPORT

EPA NUMBER:	S011308	S011704	S011710	S011904	S012213
SDG NUMBER:	SOIL	SOIL	SOIL	SOIL	SOIL
LAB ID:	P245155	P245156	P245157	P245276	P247080
DATE RECEIVED:	08/10/93	08/12/93	08/12/93	08/16/93	09/02/93
DATE ANALYZED:	8 /20/93	8 /20/93	8 /20/93	8 /20/93	9 /14/93
Units: ug/Kg					
phenol					
fluorene	39000.000	450000 ~~500000.000 DJ~~	28000.000 U	11000.000 J	1700000 ~~180000000~~
4-nitroaniline	29000.000 U	2800000 U ~~2800000.000 U~~	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
4,6-dinitro-2-methylphenol [4,6-dinitro-o-cresol]	29000.000 U	↓ ~~2800000.000 U~~	69000.000 U	140000.000 U	↓ ~~440000000.~~
N-nitrosodiphenylamine	12000.000 U	110000 U ~~1400000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
4-bromophenyl phenyl ether	12000.000 U	↓ ~~1400000.000~~ U	28000.000 U	57000.000 U	↓ ~~180000000.~~

DATE: 01/18/94
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ANALYTICAL REPORT

EPA NUMBER:	S011308	S011704	S011710	S011904	S012213
hexachlorobenzene	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
pentachlorophenol	29000.000 U	280000 U ~~2800000.000~~ U	69000.000 U	140000.000 U	2200000 U ~~440000000.~~
phenanthrene	65000.000	630000 ~~690000.000 DJ~~	28000.000 U	24000.000 J	2400000 ~~180000000.~~
anthracene	39000.000	310000 ~~370000.000 DJ~~	28000.000 U	57000.000 U	1100000 ~~180000000.~~
carbazole	14000.000	87000 J ~~1100000.000 U~~	28000.000 U	57000.000 U	360000 J ~~180000000.~~
di-n-butyl phthalate	12000.000 U	78000 J ~~1100000.000 U~~	28000.000 U	57000.000 U	890000 U ~~180000000.~~
fluoranthene	78000.000	180000 ~~210000.000 DJ~~	28000.000 U	57000.000 U	~~180000000.~~
pyrene	47000.000	110000 J ~~1100000.000 U~~	28000.000 U	11000.000 J	540000 J ~~180000000.~~
benzyl butyl phthalate	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	9400.000 J	320000 J ~~180000000.~~
3,3'-dichlorobenzidine	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	890000 U ~~180000000.~~
benzo(a)anthracene	27000.000	44000 J ~~1100000.000 U~~	28000.000 U	57000.000 U	~~180000000.~~
chrysene	26000.000	44000 J ~~1100000.000 U~~	28000.000 U	57000.000 U	~~180000000.~~
bis(2-ethylhexyl)phthalate	34000.000	86000 J ~~1100000.000 U~~	28000.000 U	57000.000 U	~~180000000.~~
di-n-octyl phthalate	12000.000 U	110000 U ~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
3,4-benzofluoranthene [benzo(b)fluoranthene]	19000.000	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
benzo(k)fluoranthene	20000.000	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
benzo(a)pyrene	17000.000	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
indeno(1,2,3-cd)pyrene	12000.000	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
dibenz(a,h)anthracene	5100.000 J	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~
benzo(g,h,i)perylene	11000.000 J	~~1100000.000~~ U	28000.000 U	57000.000 U	~~180000000.~~

MLA
1/25/94

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET

TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011308

Lab Name: NUS-LSG Contract: ______

Lab Code: NUS Case No.: AFFF SAS No.: ______ SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245155

Sample wt/vol: 4.00 (g/mL) G Lab File ID: DVP08179301

Level: (low/med) MED Date Received: 08/10/93

% Moisture: not dec. 15 Date Analyzed: 08/17/93

GC Column: DB624 ID: 0.530 (mm) Dilution Factor: 1.0

Soil Extract Volume: 10000 (uL) Soil Aliquot Volume: 100 (uL)

CONCENTRATION UNITS:

Number TICs found: 10 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 541-05-9	CYCLOTRISILOXANE, HEXAMETHYL	11.99	1300	BJN
2.	ALKYLBENZENE (MW=120)	15.67	2400	J
3.	TRIMETHYLBENZENE ISOMER	17.20	2200	J
4. 541-05-9	CYCLOTRISILOXANE, HEXAMETHYL	17.70	2900	BJN
5.	ALKENYLBENZENE (MW=118)	18.20	10000	J
6. 95-13-6	1H-INDENE	18.42	2500	JN
7. 556-67-2	CYCLOTETRASILOXANE, OCTAMETH	19.55	1200	BJN
8.	ALKYLALKENYLBENZENE (MW=160)	19.90	2500	J
9.	UNKNOWN (CONTAINS Si)	20.25	1700	J
10. 91-20-3	NAPHTHALENE	20.37	5600	JN

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011308

Lab Name: NUS-LSG Contract:

Lab Code: NUS Case No.: AFFF SAS No.: SDG No.: FKG1

Matrix: (soil/water) SOIL Lab Sample ID: F245155

Sample wt/vol: 1.00 (g/mL) G Lab File ID: ABF08209305

Level: (low/med) MED Date Received: 08/10/93

% Moisture: 15 decanted: (Y/N) N Date Extracted: 08/16/93

Concentrated Extract Volume: 500.0 (uL) Date Analyzed: 08/20/93

Injection Volume: 2.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) Y pH: 7.5

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

Number TICs found: 20

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	ISOMER (C9H10)	7.53	44000	J
2.	ALKENYLBENZENE (C10H12)+UNKN	9.44	7700	J
3. 90-12-0	NAPHTHALENE, 1-METHYL-	12.00	35000	JN
4.	DIMETHYLNAPHTHALENE ISOMER	13.32	11000	J
5.	DIMETHYLNAPHTHALENE ISOMER	13.54	19000	J
6.	DIMETHYLNAPHTHALENE ISOMER +	13.59	7700	J
7.	DIMETHYLNAPHTHALENE ISOMER	13.82	7500	J
8.	UNKNOWN	14.84	11000	J
9. 7320-53-8	DIBENZOFURAN, 4-METHYL-	16.22	7800	JN
10.	ALKENYLNAPHTHALENE (C16H18)	16.84	20000	J
11.	ISOMER (C16H18)	17.19	10000	J
12.	UNKNOWN	19.00	7500	J
13.	METHYLPHENANTHRENE ISOMER+UN	19.47	7300	J
14.	PAH (C15H12)	19.54	8900	J
15.	PAH (C15H10)+PAH (C15H12)	19.75	23000	J
16.	METHYLPYRENE ISOMER + PAH (C	22.75	18000	J
17.	PAH (C17H12)	22.92	9300	J
18.	UNKNOWN	23.04	11000	J
19.	PAH (C20H12)	28.81	11000	J
20.	UNKNOWN	29.82	8800	J

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011704

Lab Name: NUS-LSG   Contract: ______

Lab Code: NUS   Case No.: AFFF   SAS No.: ______   SDG No.: PKG1

Matrix: (soil/water) SOIL   Lab Sample ID: P245156

Sample wt/vol: 4.00 (g/mL) G   Lab File ID: DVP08179302

Level: (low/med) MED   Date Received: 08/12/93

% Moisture: not dec. 10   Date Analyzed: 08/17/93

GC Column: DB624   ID: 0.530 (mm)   Dilution Factor: 1.0

Soil Extract Volume: 10000 (uL)   Soil Aliquot Volume: 100 (uL)

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

Number TICs found: 10

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	METHYLETHYLBENZENE ISOMER	15.67	11000	J
2.	ETHYLMETHYLBENZENE ISOMER	16.52	18000	J
3.	TRIMETHYLBENZENE ISOMER	16.62	15000	J
4.	TRIMETHYLBENZENE ISOMER	17.19	27000	J
5.	ALKENYLBENZENE (MW=118)	18.17	39000	J
6.	ALKYNYLBENZENE (MW=116)	18.40	14000	J
7.	ALKYLBENZENE (MW=134)+UNKNOW	19.19	15000	J
8.	UNKNOWN	19.69	16000	J
9.	ALKYLBENZENE (MW=162)+UNKNOW	19.95	11000	J
10. 91-20-3	NAPHTHALENE	20.37	180000	JN

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET

TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011704DL

Lab Name: NUS-LSG Contract: ______

Lab Code: NUS Case No.: AFFP SAS No.: ______ SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245156DL

Sample wt/vol: 4.00 (g/mL) G Lab File ID: DVP08179305

Level: (low/med) MED Date Received: 08/12/93

% Moisture: not dec. 10 Date Analyzed: 08/17/93

GC Column: DB624 ID: 0.530 (mm) Dilution Factor: 2.0

Soil Extract Volume: 10000 (uL) Soil Aliquot Volume: 100 (uL)

CONCENTRATION UNITS:

Number TICs found: 10 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	METHYLETHYLBENZENE ISOMER	15.67	11000	J
2.	ETHYLMETHYLBENZENE ISOMER	16.52	17000	J
3.	TRIMETHYLBENZENE ISOMER	16.64	11000	J
4.	TRIMETHYLBENZENE ISOMER	17.20	25000	J
5.	METHYLPROPYLBENZENE ISOMER	17.49	5100	J
6.	ALKENYLBENZENE (MW=118)	18.20	35000	J
7.	ALKYNYLBENZENE (MW=116)	18.40	11000	J
8.	ALKYLBENZENE (MW=134)+UNKNOW	19.19	18000	J
9.	UNKNOWN	19.69	12000	J
10. 91-20-3	NAPHTHALENE	20.37	270000	JN

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011704

Lab Name: NUS-LSG Contract:

Lab Code: NUS Case No.: AFFP SAS No.: SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245156

Sample wt/vol: 1.00 (g/mL) G Lab File ID: ABP08209303

Level: (low/med) MED Date Received: 08/12/93

% Moisture: 10 decanted: (Y/N) N Date Extracted: 08/16/93

Concentrated Extract Volume: 500.0 (uL) Date Analyzed: 08/20/93

Injection Volume: 2.0(uL) Dilution Factor: 10.0

GPC Cleanup: (Y/N) Y pH: 8.0

CONCENTRATION UNITS:
Number TICs found: 20 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	ISOMER (C9H10)	7.53	250000	J
2. 95-13-6	1H-INDENE	7.68	170000	JN
3. 95-15-8	BENZO[B]THIOPHENE	10.19	210000	JN
4.	UNKNOWN (MW=176)	11.22	200000	J
5. 2132-84-5	BENZENE, (1-METHYLHEXYL)-	11.65	190000	JN
6. 90-12-0	NAPHTHALENE, 1-METHYL-	12.02	650000	JN
7.	ALKYLBENZENE (C14H22)	12.62	160000	J
8. 92-52-4	1,1'-BIPHENYL	12.95	290000	JN
9.	DIMETHYLNAPHTHALENE ISOMER	13.32	220000	J
10.	DIMETHYLNAPHTHALENE ISOMER	13.54	330000	J
11.	DIMETHYLNAPHTHALENE ISOMER+A	13.60	160000	J
12.	ALKYLBENZENE (C15H24)	13.90	190000	J
13.	UNKNOWN (MW=188)	14.35	310000	J
14. 90-43-7	[1,1'-BIPHENYL]-2-OL	14.82	640000	JN
15.	ALKENYLNAPHTHALENE (C16H18)	16.87	1500000	J
16.	ISOMER (C16H18)	17.20	500000	J
17.	ISOMER (C16H16)+UNKNOWN (MW=	17.97	220000	J
18.	AROMATIC (MW=224)	18.09	170000	J
19.	AROMATIC (MW=208)+UNKNOWN (M	23.95	220000	J
20.	AROMATIC (MW=208)+UNKNOWN (M	24.19	210000	J

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011704DL

Lab Name: NUS-LSG Contract:

Lab Code: NUS Case No.: AFFP SAS No.: SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245156DL

Sample wt/vol: 1.00 (g/mL) G Lab File ID: ABP08209307

Level: (low/med) MED Date Received: 08/12/93

% Moisture: 10 decanted: (Y/N) N Date Extracted: 08/16/93

Concentrated Extract Volume: 500.0 (uL) Date Analyzed: 08/20/93

Injection Volume: 2.0(uL) Dilution Factor: 100.0

GPC Cleanup: (Y/N) Y pH: 8.0

CONCENTRATION UNITS:

Number TICs found: 14 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	TRIMETHYLBENZENE ISOMER	6.78	330000	J
2.	ISOMER (C9H10)	7.53	260000	J
3. 95-15-8	BENZO[B]THIOPHENE	10.19	270000	JN
4.	UNKNOWN (MW=176)	11.22	240000	J
5. 2132-84-5	BENZENE, (1-METHYLHEXYL)-	11.65	230000	JN
6. 90-12-0	NAPHTHALENE, 1-METHYL-	12.02	760000	JN
7. 92-52-4	1,1'-BIPHENYL	12.95	310000	JN
8.	DIMETHYLNAPHTHALENE ISOMER	13.54	310000	J
9. 90-43-7	[1,1'-BIPHENYL]-2-OL	14.80	550000	JN
10.	AROMATIC (C15H16)	15.77	440000	J
11.	ALKENYLNAPHTHALENE (C16H18)	16.87	2600000	J
12.	ISOMER (C16H18)	17.20	630000	J
13.	ISOMER (C16H16)+UNKNOWN (MW=	17.97	460000	J
14.	UNKNOWN	23.95	240000	J

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011710

Lab Name: NUS-LSG Contract:

Lab Code: NUS Case No.: AFFF SAS No.: SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245157

Sample wt/vol: 4.00 (g/mL) G Lab File ID: DVP08169303

Level: (low/med) MED Date Received: 08/12/93

% Moisture: not dec. 42 Date Analyzed: 08/17/93

GC Column: DB624 ID: 0.530 (mm) Dilution Factor: 1000.0

Soil Extract Volume: 10000 (uL) Soil Aliquot Volume: 100 (uL)

Number TICs found: 7

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 541-05-9	CYCLOTRISILOXANE, HEXAMETHYL	11.97	2000000	BJN
2. 556-67-2	CYCLOTETRASILOXANE, OCTAMETH	15.77	2100000	BJN
3.	UNKNOWN (CONTAINS Si)	17.20	2400000	BJ
4. 541-05-9	CYCLOTRISILOXANE, HEXAMETHYL	17.70	3100000	BJN
5. 541-02-6	CYCLOPENTASILOXANE, DECAMETH	18.37	1300000	BJN
6.	UNKNOWN (CONTAINS Si)	20.25	5200000	BJ
7. 91-20-3	NAPHTHALENE	20.37	1200000	JN

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011710

Lab Name: NUS-LSG Contract: ____

Lab Code: NUS Case No.: AFFP SAS No.: ____ SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: P245157

Sample wt/vol: 30.00 (g/mL) G Lab File ID: ABP08209308

Level: (low/med) LOW Date Received: 08/12/93

% Moisture: 42 decanted: (Y/N) N Date Extracted: 08/16/93

Concentrated Extract Volume: 500.0 (uL) Date Analyzed: 08/20/93

Injection Volume: 2.0 (uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) Y pH: 1.1

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

Number TICs found: 19

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 141-79-7	3-PENTEN-2-ONE, 4-METHYL-	3.48	11000	ABJN
2.	TRIMETHYLBENZENE ISOMER	6.80	7800	J
3.	ISOMER (C9H10)+ALKYLBENZENE	7.55	6800	J
4.	ALKYLBENZENE (C11H16)	8.45	7100	J
5.	ALKYLBENZENE (C12H18)	10.19	7800	J
6.	UNKNOWN (MW=176)	11.24	8100	J
7. 2132-84-5	BENZENE, (1-METHYLHEXYL)-	11.65	11000	JN
8. 90-12-0	NAPHTHALENE, 1-METHYL-	12.02	7600	JN
9. 827-52-1	BENZENE, CYCLOHEXYL-	12.10	17000	JN
10.	UNKNOWN (MW=190)	12.60	14000	J
11.	UNKNOWN (MW=190)	13.04	8000	J
12.	UNKNOWN (MW=190)	13.09	8800	J
13.	UNKNOWN (MW=174)	13.55	16000	J
14.	UNKNOWN (MW=174)	13.60	15000	J
15.	ALKYLBENZENE (C15H24)	13.94	12000	J
16.	UNKNOWN	14.37	14000	JX
17. 143-07-7	DODECANOIC ACID	15.14	16000	BJN
18. 13540-56-2	BENZENE, 1,2-DIMETHYL-4-(PHE	15.82	14000	JN
19.	ALKENYLNAPHTHALENE (C15H18)	16.87	11000	J

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET

TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

SO11904

Lab Name: NUS-LSG Contract:

Lab Code: NUS Case No.: AFFP SAS No.: SDG No.: PKG1

Matrix: (soil/water) SOIL Lab Sample ID: F245276

Sample wt/vol: 4.00 (g/mL) G Lab File ID: DVP08249301

Level: (low/med) MED Date Received: 08/16/93

% Moisture: not dec. 13 Date Analyzed: 08/24/93

GC Column: DB624 ID: 0.530 (mm) Dilution Factor: 4.0

Soil Extract Volume: 10000 (uL) Soil Aliquot Volume: 100 (uL)

CONCENTRATION UNITS:

Number TICs found: 10 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	ETHYLMETHYLBENZENE ISOMER	16.47	73000	J
2.	TRIMETHYLBENZENE ISOMER	16.57	43000	J
3.	TRIMETHYLBENZENE ISOMER	17.14	110000	J
4.	ALKYLBENZENE (MW=134)	17.55	30000	J
5.	ALKYLBENZENE (MW=120)	17.79	22000	J
6.	ALKENYLBENZENE (MW=118)+ALKY	18.15	74000	J
7.	ALKYLALKYNYLBENZENE (MW=116)	18.35	92000	J
8.	ALKENYLBENZENE (MW=132)	19.14	30000	J
9.	UNKNOWN	19.70	15000	J
10. 91-20-3	NAPHTHALENE	20.32	260000	JN

1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

S011904

Lab Name: NUS-LSG   Contract: ______

Lab Code: NUS   Case No.: AFFP   SAS No.: ______   SDG No.: PKG1

Matrix: (soil/water) SOIL   Lab Sample ID: P245276

Sample wt/vol: 1.00 (g/mL) G   Lab File ID: ABP08209306

Level: (low/med) MED   Date Received: 08/16/93

% Moisture: 13   decanted: (Y/N) N   Date Extracted: 08/17/93

Concentrated Extract Volume: 500.0 (uL)   Date Analyzed: 08/20/93

Injection Volume: 2.0(uL)   Dilution Factor: 5.0

GPC Cleanup: (Y/N) Y   pH: 11.2

CONCENTRATION UNITS:
Number TICs found: 5   (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	TRIMETHYLBENZENE ISOMER	6.80	30000	J
2. 271-89-6	BENZOFURAN	6.85	16000	JN
3. 95-13-6	1H-INDENE	7.68	54000	JN
4. 95-15-8	BENZO[B]THIOPHENE	10.19	14000	JN
5. 90-12-0	NAPHTHALENE, 1-METHYL-	12.02	23000	JN

Halliburton NUS CORPORATION

INTERNAL CORRESPONDENCE

DEC - 6

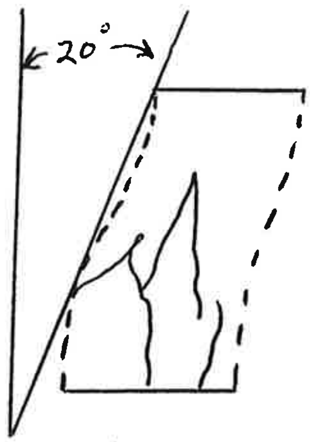
C-28-93-CFK-1227

TO:	**PAUL PERSING**	**DATE:**	**DECEMBER 2, 1993**
FROM:	**CHUCK KOVACH** CK	**COPIES:**	**J. SAMCHUCK** **G. SARACHINE/CLIENT FILE**

SUBJECT: ALLIED FIBER FRANKFORD PLANT GEOTECHNICAL DATA

Enclosed is the geotechnical data for the three samples submitted from the Allied Fiber Frankford Plant. Analyses included permeability, unconfined compressive strength, and grain size (sieve and hydrometer). Also included are the curves associated with the unconfined compressive strength and grain size determinations. I have submitted a copy of the data to J. Samchuck at Foster Plaza, should any validation be required. If you have any questions regarding the geotechnical data, feel free to contact met at (412) 747-2583.

UNCONFINED COMPRESSIVE STRENGTH CURVES



P252909

S0302-19

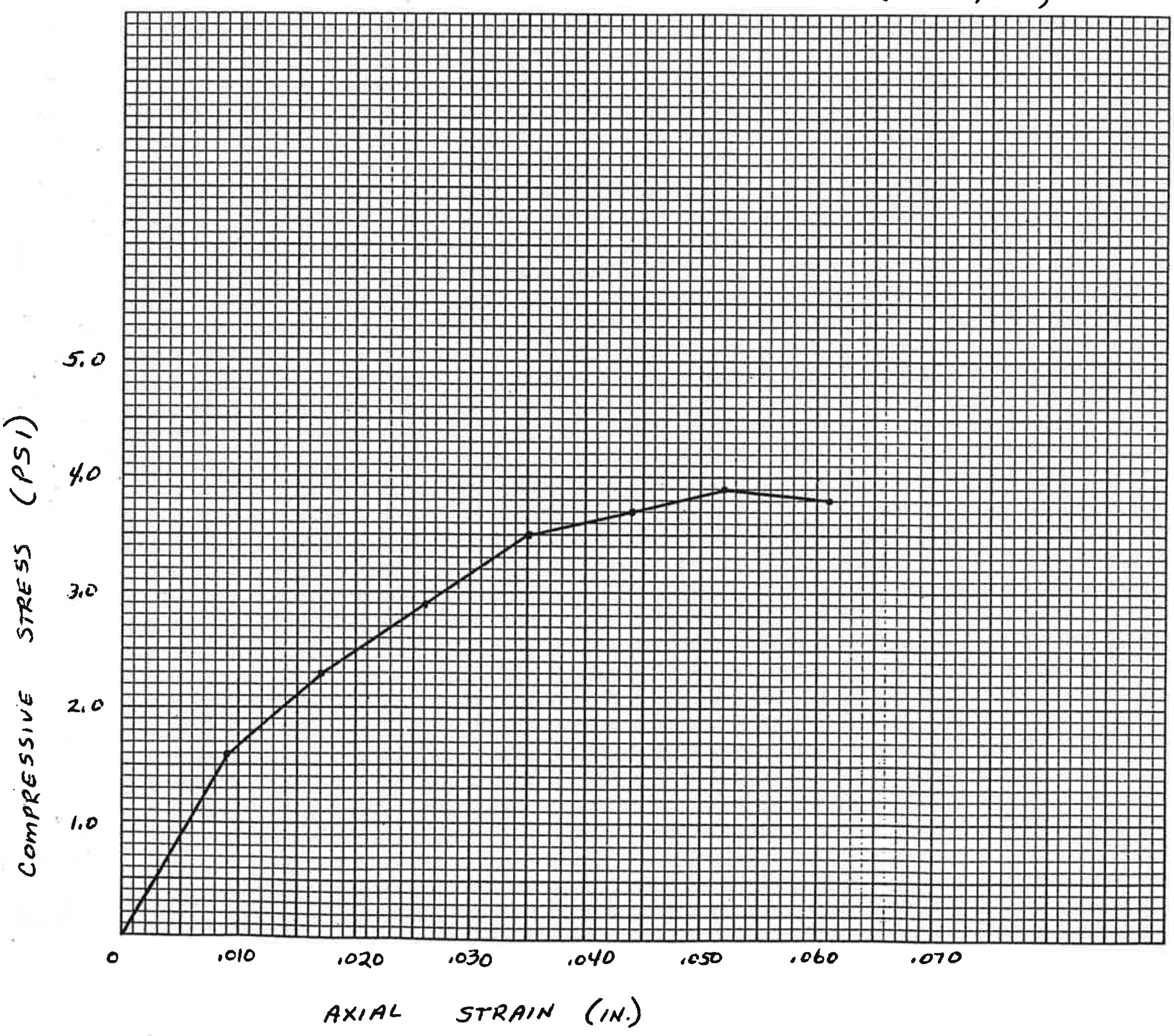
UNCONFINED COMPRESSIVE STRENGTH = 3.9 PSI

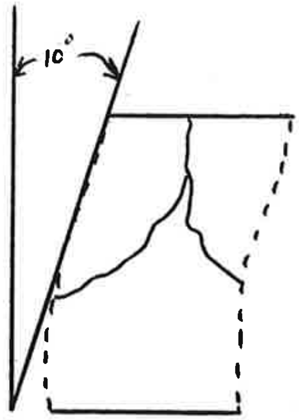
$\frac{L}{D} = 2.0$

D = 2.85"

L = 5.72"

STRAIN RATE = 1.7%/MIN.
(0.100"/MIN)





P252910

SODB-3-17

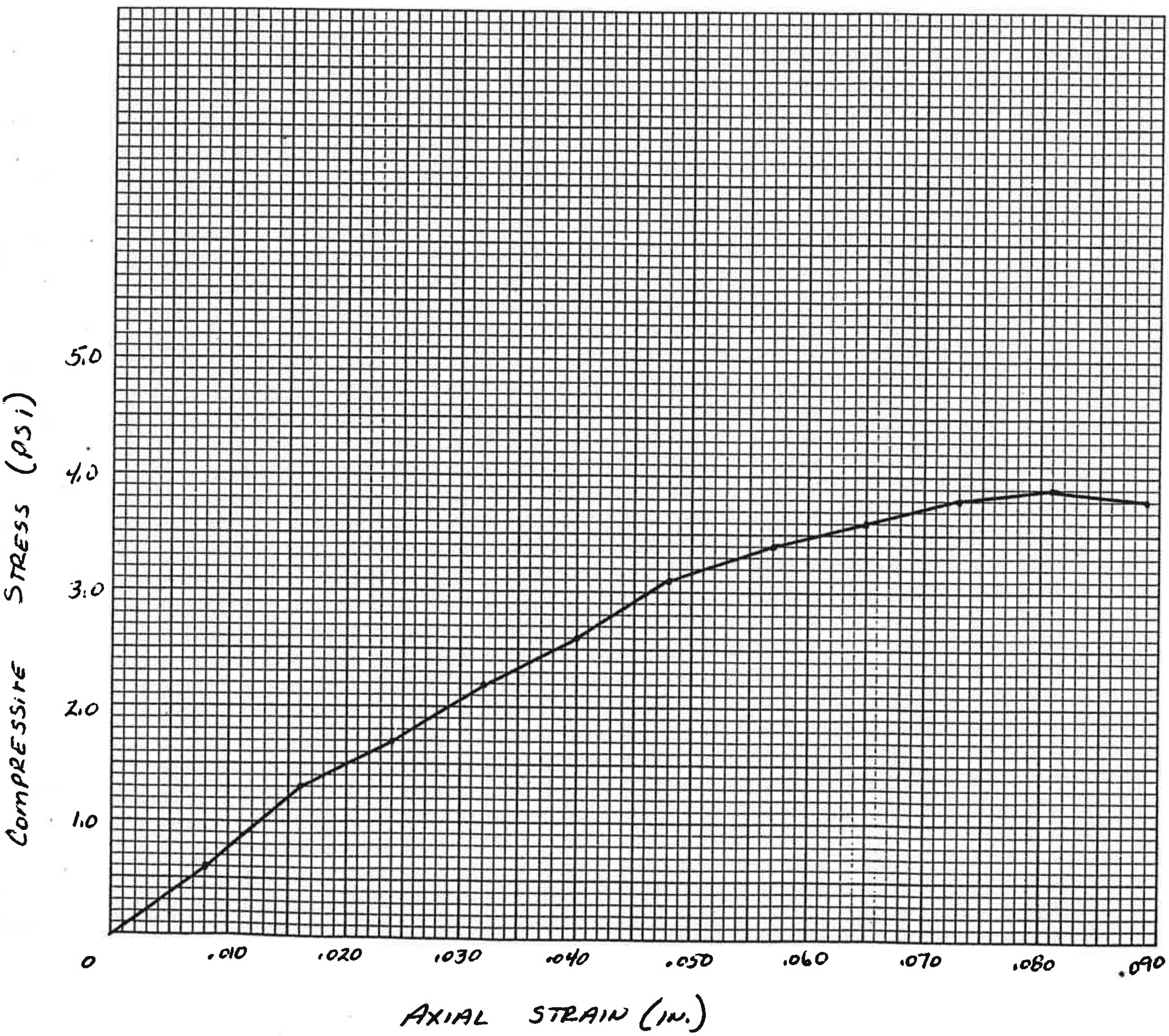
UNCONFINED COMPRESSIVE STRENGTH = 3.9 PSI

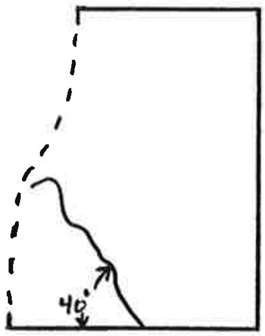
$\frac{L}{D} = 2.2$

D = 2.80 IN.

L = 6.19 IN.

STRAIN RATE = 1.16 %/MIN.
(0.100 "/MIN)





P252911

S0305-11

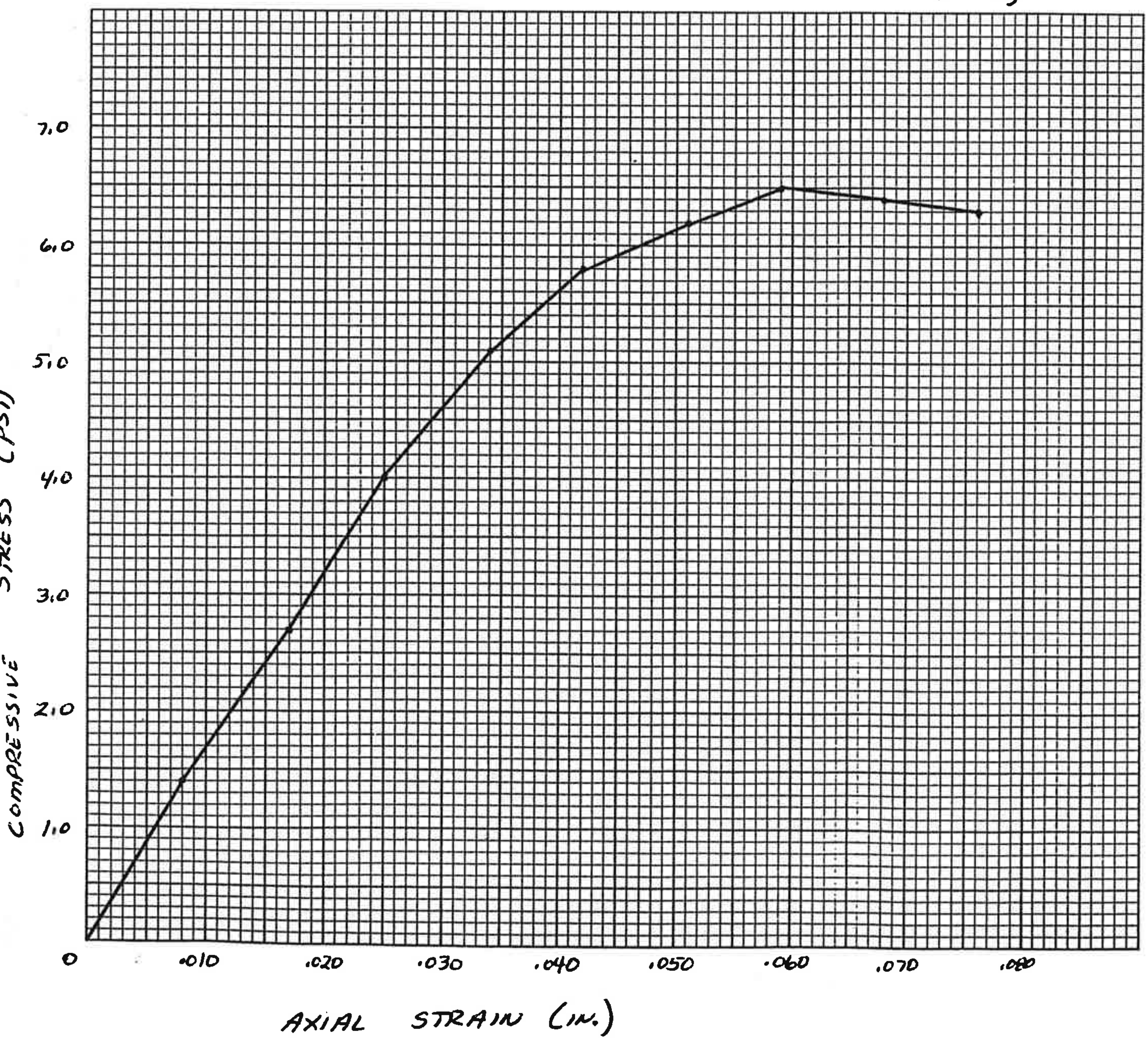
UNCONFINED COMPRESSIVE STRENGTH = 6.5 PSI

$\frac{L}{D} = 2.1$

D = 2.82 IN.

L = 5.91 IN.

STRAIN RATE = 1.7%/MIN.
(0.100"/MIN)



CURVES FOR GRAIN SIZE
SIEVE AND HYDROMETER

NUS CORPORATION

Laboratory No. P25 2909

Sheet ____ of ____

Project Name ____ Project No. ____ Tested by JCL/DS date 11-2-93

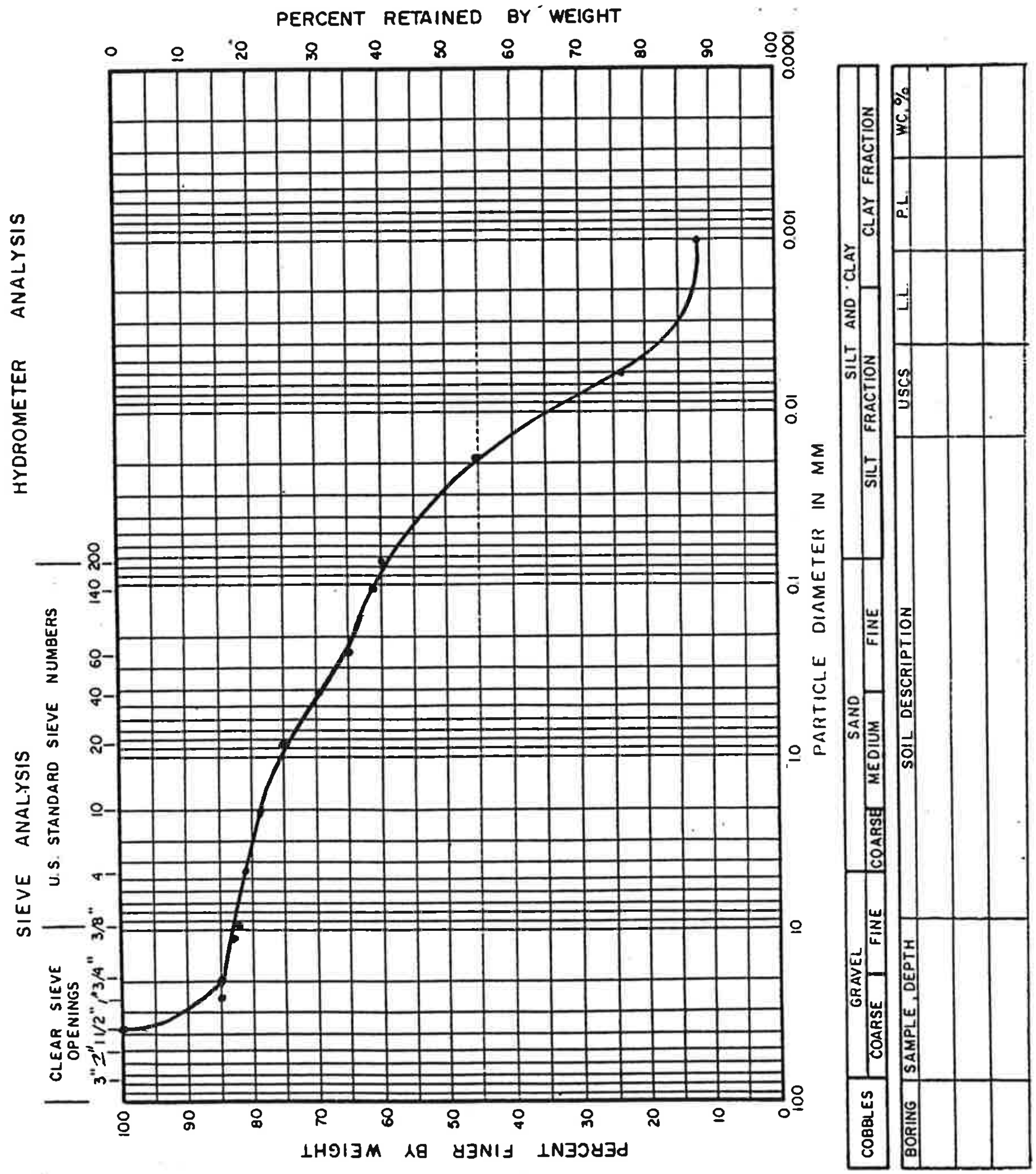
Boring/Test Pit No. ____ Sample No. ____ Calculated by JCL date 11-23-93

Sample Depth ____ Sample Type ____ Checked by JCL date 11-24-93

Sample Description ____

Sample Preparation Method ____

GRAIN SIZE ANALYSIS
COHESIVE MATERIAL



P368-92

DATA IN BOOK P303-92 PG 97

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NUS CORPORATION

Laboratory No. P252910

Sheet ____ of ____

Project Name ____ Project No. ____ Tested by JCL/MDS date 11-2-93

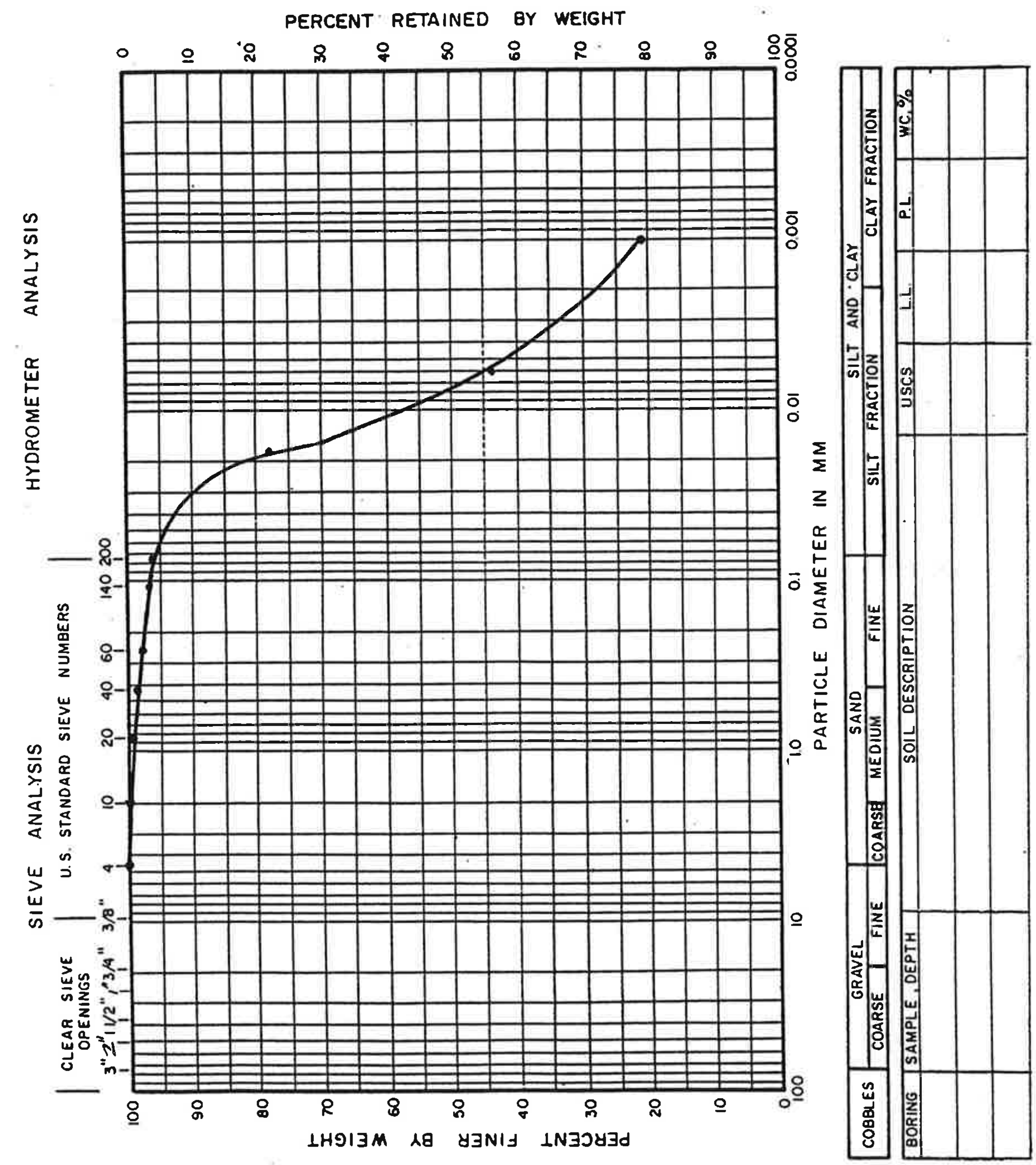
Boring/Test Pit No. ____ Sample No. ____ Calculated by JCL date 11-23-93

Sample Depth ____ Sample Type ____ Checked by JCL date 11-24-94

Sample Description ____

Sample Preparation Method ____

GRAIN SIZE ANALYSIS
COHESIVE MATERIAL



P368-92

DATA IN BOOK P303-92 PG 98

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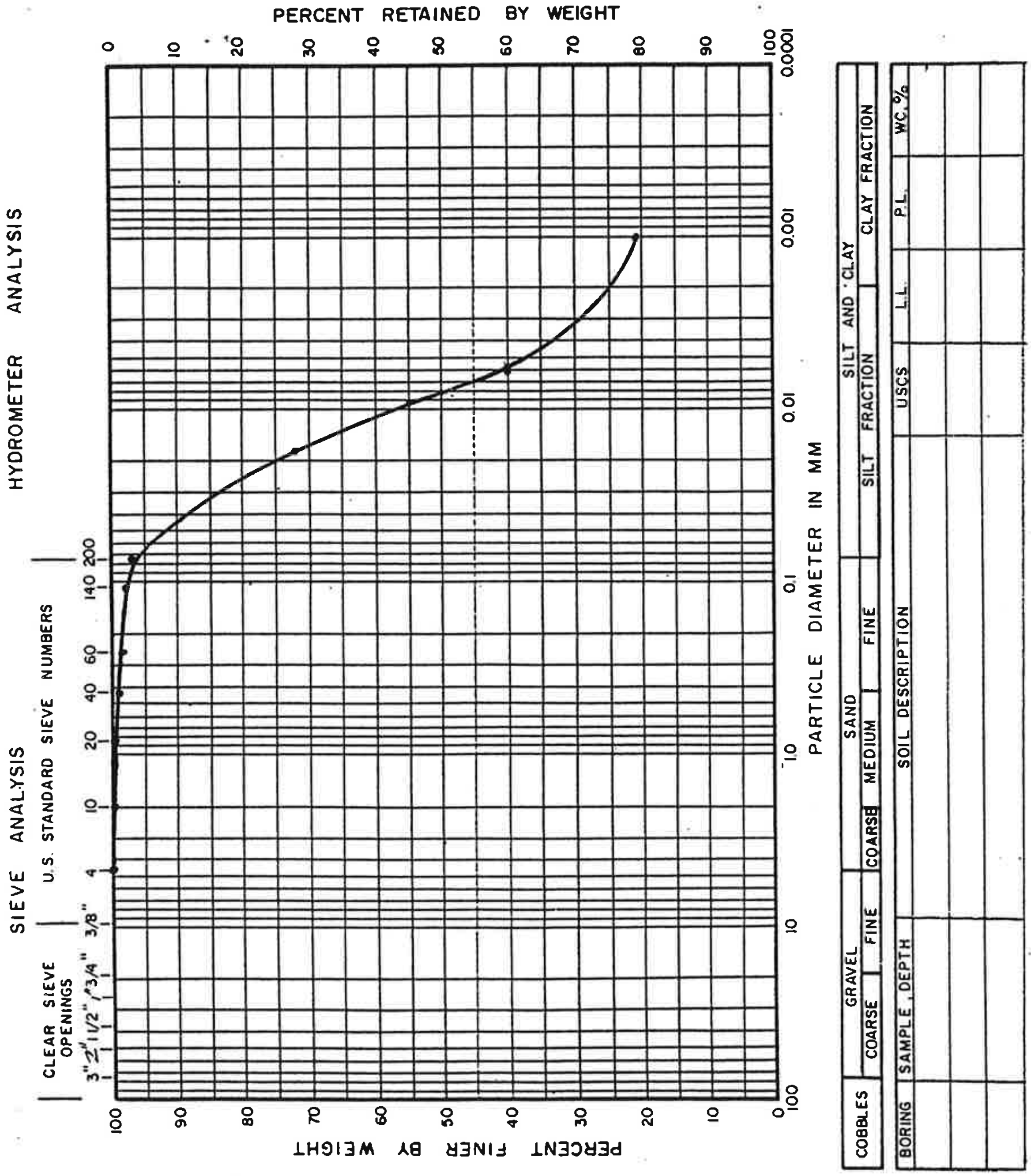
NUS CORPORATION

Laboratory No. P252911
Sheet ______ of ______

Project Name ______ Project No. ______ Tested by JCL/MDS date 11-2-93
Boring/Test Pit No. ______ Sample No. ______ Calculated by JCL date 11-23-93
Sample Depth ______ Sample Type ______ Checked by JCL date 11-24-94
Sample Description ______
Sample Preparation Method ______

GRAIN SIZE ANALYSIS
COHESIVE MATERIAL



P368-92

DATA IN BOOK P303-92 PG 99

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CHAIN-OF-CUSTODY FORM

Halliburton NUS CORPORATION

NUS LABORATORY

CHAIN OF CUSTODY RECORD

PROJECT NO.: 0091. 0402

SITE NAME: ALLIED FRANKFORD PLANT; PHASE II REI

SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	CONSTANT HEAD PERMEABILITY	UNCONFINED COMP. STRENGTH	GRAIN SIZE				REMARKS
302	8/20/93	0900		✓	SO302-19	1		1					SHELBY TUBE
DB-3	9/3/93	1100		✓	SO DB-3-17	1		1					SHELBY TUBE - POSSIBLE CONTAMINATION
305	9/13/93	1010		✓	SO305-11	1		1					SHELBY TUBE - HIGH HNU READINGS, STRONG CHEMICAL ODOR

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):
[signature]	10-28-93 1600				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE): M Bartolovic	DATE / TIME: 11/1 0930	REMARKS: SHIPPED VIA FEDERAL EXPRESS AIRBILL NO. 9664499513	

NUS 440 REVISED 0891

Halliburton NUS CORPORATION

NUS LABORATORY
Two Marquis Office Plaza, Suite 200
5313 Campbells Run Road
Pittsburgh, Pennsylvania 15205

(412) 747-2580
FAX: (412) 747-2684

November 29, 1993
Report No.: 00018096
Section A Page 1

LABORATORY ANALYSIS REPORT

CLIENT NAME: ALLIED FIBERS - C/O HALLIBURTON NUS CORPORATION
ADDRESS: 993 OLD EAGLE SCHOOL ROAD, STE 4
WAYNE, PA 19087-1970
ATTENTION: PAUL PERSING

NUS CLIENT NO: 1508 0004
WORK ORDER NO: 0091
VENDOR NO:

Carbon Copy:

SAMPLE ID: S0302-19
NUS SAMPLE NO: P0252909
P.O. NO.:

DATE SAMPLED: 20-AUG-93
DATE RECEIVED: 01-NOV-93
APPROVED BY: Kieda, Chuck

LN	TEST CODE	DETERMINATION	RESULT	UNIT
1	T67	Permeability - undisturbed	1.6 x 10-7	cm/s
2	T75	Unconfined compressive strength	3.9	psi
3	T45	Grain Size - Sieve & Hydrometer		
		b. 1.5 inch sieve	100.0	% Passed
		c. 1.0 inch sieve	84.9	% Passed
		d. 3/4 inch sieve	84.9	% Passed
		e. 1/2 inch sieve	82.7	% Passed
		f. 3/8 inch sieve	82.3	% Passed
		g. Sieve No. 4	80.8	% Passed
		h. Sieve No. 10	78.7	% Passed
		i. Sieve No. 20	74.8	% Passed
		j. Sieve No. 40	69.6	% Passed
		k. Sieve No. 60	64.8	% Passed
		l. Sieve No. 140	60.8	% Passed
		m. Sieve No. 200	59.9	% Passed
		n. Particle Size .019 mm	45.6	% Passed
		o. Particle Size .006 mm	23.6	% Passed
		p. Particle Size .001 mm	11.8	% Passed

COMMENTS:

Halliburton NUS CORPORATION

NUS LABORATORY
Two Marquis Office Plaza, Suite 200
5313 Campbells Run Road
Pittsburgh, Pennsylvania 15205

(412) 747-2580
FAX: (412) 747-2684

November 29, 1993
Report No.: 00018096

LABORATORY ANALYSIS REPORT

CLIENT NAME: ALLIED FIBERS - C/O HALLIBURTON NUS CORPORATION
ADDRESS: 993 OLD EAGLE SCHOOL ROAD, STE 4
WAYNE, PA 19087-1970
ATTENTION: PAUL PERSING

NUS CLIENT NO: 1508 0004
WORK ORDER NO: 0091
VENDOR NO:

Carbon Copy:

SAMPLE ID: SODB-3-17
NUS SAMPLE NO: P0252910
P.O. NO.:

DATE SAMPLED: 03-SEP-93
DATE RECEIVED: 01-NOV-93
APPROVED BY: Kieda, Chuck

LN	TEST CODE	DETERMINATION	RESULT	UNITS
1	T67	Permeability - undisturbed	1.1 x 10-7	cm/s
2	T75	Unconfined compressive strength	3.9	psi
3	T45	Grain Size - Sieve & Hydrometer		
		g. Sieve No. 4	100.0	% Passed
		h. Sieve No. 10	99.9	% Passed
		i. Sieve No. 20	99.7	% Passed
		j. Sieve No. 40	99.1	% Passed
		k. Sieve No. 60	98.4	% Passed
		l. Sieve No. 140	97.2	% Passed
		m. Sieve No. 200	96.6	% Passed
		n. Particle Size .018 mm	77.9	% Passed
		o. Particle Size .006 mm	44.0	% Passed
		p. Particle Size .001 mm	21.0	% Passed

COMMENTS:

Halliburton NUS CORPORATION

NUS LABORATORY
Two Marquis Office Plaza, Suite 200
5313 Campbells Run Road
Pittsburgh, Pennsylvania 15205

(412) 747-2580
FAX: (412) 747-2684

QUALITY CONTROL REPORT
SUPPLEMENTAL INFORMATION

			SAMPLE PREPARATION			SAMPLE ANALYSIS				
LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT

SAMPLE ID: S0302-19 NUS SAMPLE NO: P0252909

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1000	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

LR Method Literature Reference
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

SAMPLE ID: SODB-3-17 NUS SAMPLE NO: P0252910

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1030	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

LR Method Literature Reference
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

SAMPLE ID: S0305-11 NUS SAMPLE NO: P0252911

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1100	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

LR Method Literature Reference
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

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November 29, 1993
Report No.: 00018096

QUALITY CONTROL REPORT
SUPPLEMENTAL INFORMATION

			SAMPLE PREPARATION			SAMPLE ANALYSIS				
LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT

SAMPLE ID: S0302-19 NUS SAMPLE NO: P0252909

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1000	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

<u>LR</u> <u>Method Literature Reference</u>
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

SAMPLE ID: SODB-3-17 NUS SAMPLE NO: P0252910

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1030	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

<u>LR</u> <u>Method Literature Reference</u>
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

SAMPLE ID: S0305-11 NUS SAMPLE NO: P0252911

LN	TEST CODE	BATCH	LR-METHOD	DATE/TIME	ANALYST	LR-METHOD	DATE/TIME	ANALYST	ANLS BATCH	INSTRUMENT
1	T67	0	NA			19-9100	04-NOV-93 700	JCL	0	
2	T75	0	NA			01-D2166	03-NOV-93 1100	JCL	0	
3	T45	0	NA			01-D422	02-NOV-93 630	JCL	0	

<u>LR</u> <u>Method Literature Reference</u>
01 ASTM-American Society for Testing and Materials, Part 31, 1979.
19 EPA-Test Methods for Evaluating Solid Waste, 3rd ed, Nov. 1986

SAMPLING AND ANALYSIS PL
FOR A
RCRA FACILITY INVESTIGATIO
(RFI)

VOLUME 2 of 3

Prepared for

Allied Signal

FIBERS DIVISION
Margaret and Bermuda Streets
Philadelphia, Pennsylvania 19137-1193

Prep

May 10, 1991

Copy Control No. 4

RCRA FACILITY INVESTIGATION PLAN

VOLUME 2 OF 3
SAMPLING AND ANALYSIS PLAN

ALLIED-SIGNAL INC.
FIBERS DIVISION, FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

EPA PERMIT NUMBER PAD002312791

ALLIED-SIGNAL CONTRACT NUMBER 53C-81027

NUS PROJECT NUMBER 3082

MAY 1991

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ALLIED FIBERS FRANKFORD PLANT

CERTIFICATION

"I certify that the information contained in or accompanying this submission is true, accurate, and complete.

As to those identified portions of this submission for which I cannot personally verify their truth and accuracy, I certify, as the company official having supervisory responsibility for the persons who, acting under my direct instructions, made the verification, that this information is true, accurate, and complete."

John S. Bresland

John S. Bresland
Plant Manager
Allied-Signal Inc.
Allied Fibers Frankford Plant

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FIBERS DIVISION, FRANKFORD PLANT
RCRA FACILITY INVESTIGATION
VOLUME 2 - SAMPLING AND ANALYSIS PLAN

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Barbara Flowers	Allied-Signal Inc.	5 - 8
Dennis Beissel, CPG	NUS Corporation	9
John Trepanowski, P.E.	NUS Corporation	10
Project File	NUS Corporation	11
Joseph Feola	PADER	12

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1.0 PROJECT DESCRIPTION

This Sampling and Analysis Plan (Volume 2 of 3) provides guidance for the initial phase of RCRA Facility Investigation (RFI) activities at the Allied Fibers facility in Philadelphia, Pennsylvania, and includes the elements required for a Quality Assurance Project Plan (EPA, 1980). This section provides a brief review of the facility history and description as well as the scope of work for the RFI.

1.1 FACILITY LOCATION

The Allied Fibers facility is located in northeastern Philadelphia at approximately 40°00'24" north latitude and 75°04'07" west longitude. The property is bounded on the west by Margaret Street; on the north by Interstate 95; on the east by Bridge Street; and on the south by the Frankford Inlet, the Frankford Inlet Sewer right-of-way, and Almond, Pratt, Belgrade, Ash, and Gaul Streets. The Frankford Inlet discharges to the Delaware River approximately one-half mile east of the facility. Both the Frankford Inlet and the Delaware River are tidal in the reaches near the facility.

The Frankford facility lies in the Bridesburg section of Philadelphia, Pennsylvania. Immediately adjoining the facility to the south is a densely populated residential area. A mixed residential/industrial area lies across Interstate 95 to the north of the facility. The TIP Trailer sales lot is located immediately west of the plant. The Frankford Arsenal and Rohm & Haas Delaware Valley, Inc., Philadelphia chemical plant are located east of the plant.

The Allied property is generally flat and is situated 5 to 15 feet above mean sea level. The property gradually slopes to the south, toward the former Frankford Creek creekbed.

1.2 FACILITY DESCRIPTION

Currently, the Frankford Plant is primarily a manufacturer of phenol and acetone, using the cumene process. Frankford is the largest producer of synthetic phenol and acetone at one location in the United States. Phenol and acetone are principally used in the manufacture of polymers, fibers, resins, varnishes, etc. Limited quantities of alpha-methylstyrene and cumene hydroperoxide, byproducts of the cumene process, are also produced.

Additional information about the facility, as well as information about the study areas and units to be investigated during the RFI, can be found in the RCRA Facility Investigation Scoping Document (Volume I of this RFI Plan).

1.3 SCOPE OF WORK

The objectives and scope of work for the Phase I RFI are presented in Section 2.0 of this volume. The schedule for Phase I RFI activities is included in the Project Management Plan (Section 1.0 of Volume 3 of this RFI Plan).

2.0 FIELD INVESTIGATION TECHNICAL APPROACH

2.1 PHASED RFI TECHNICAL APPROACH

2.1.1 Objectives of Phase I RFI

The overall objective of the RFI is to determine the nature and extent of releases of hazardous waste or constituents from the SWMUs/AOCs identified in the USEPA RCRA Corrective Action Permit, and to gather the necessary data to support the Corrective Measures Study. Limited data are currently available for the study areas and units under consideration in this RFI. As indicated in the RCRA Facility Investigation Scoping Document (Volume I of this RFI Plan), environmental sampling data are available only for Study Area 1, and these data do not adequately characterize the contamination in this study area. No environmental data are available for the other three study areas. Therefore, it is not possible at this time to completely scope the RFI to meet the overall RFI objectives.

The RFI will be conducted in phases to optimize data collection activities. The scope of work for the Phase I RFI is summarized in Table 2-1 and presented in greater detail in this section. The need for, and scope of, additional phases of the RFI will be determined after evaluation of the Phase I RFI data.

2.1.2 Rationale for Additional RFI Phases

In general, the contaminant migration pathway of most concern at the four study areas is groundwater contaminant transport, with potential discharge to surface water. With the exception of Study Area 1, there are no groundwater data available. In Study Area 1, where groundwater data are available, the Phase I RFI involves the installation of shallow monitoring wells to further characterize contamination in the water table aquifer, and performance of slug tests and a comprehensive water-level measurement program to help establish the shallow groundwater flow regime and determine the interconnection between shallow groundwater and surface water.

For Study Area 1, if groundwater data and risk analysis indicate the need for additional data, consideration will be given to the following:

- Deeper wells to define the vertical extent of groundwater contamination.
- Additional wells to define the horizontal extent of contamination.
- Surface-water sampling in Frankford Inlet.

TABLE 2-1

RFI SCOPING MATRIX
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

Suggested Study Area	SWMU/ AOC No(s)	SWMU/AOC Name	Suspected Contaminants or Source	Existing Contaminant Data	RFI Phase I Approach	RFI Phase I Analytical Scheme
1	AOC-1	Groundwater Recovery Wells	Cumene, Other Organics, Selected Metals	Two sample rounds of floating product (cumene). One sample round from recovery wells. Data indicate groundwater contamination.	1) Inspect existing wells for usability. These include wells B1A, B2, B3, and B4 in the Unit 2 process area and the caustic spill area wells. 2) Continuously sample 12 soil borings to collect geological information, define the extent of the floating product layer (LNAPL) and generate estimates of product thickness. Field screen samples visually and with an HNU. 3) Install and collect samples from three stainless steel monitoring wells screened across the uppermost waterbearing zone. These wells would be located as follows: - 1 well upgradient of the LNAPL area - 2 wells downgradient of the LNAPL area 4) Perform slug tests on new wells. 5) Install 2 staff gages in Frankford Inlet. 6) Survey and obtain water levels from all usable wells. 7) Validate existing data from recovery wells.	Groundwater Analyses: Target Compound List (TCL) volatiles, semivolatiles, and pesticide/PCBs; Target Analyze List (TAL) metals; Appendix IX organophosphorus pesticides, herbicides, and dioxin screen; and TOC. Metals samples will be field-filtered. Three samples (exclusive of QA/QC samples) total.
	46	Phenol Water System	None. EPA suspects leaks occurred in the past.			

TABLE 2-1
RFI SCOPING MATRIX
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE TWO

<table>
<tr><th>Suggested Study Area</th><th>SWMU/ AOC No(s)</th><th>SWMU/AOC Name</th><th>Suspected Contaminants or Source</th><th>Existing Contaminant Data</th><th>RFI Phase I Approach</th><th>RFI Phase I Analytical Scheme</th></tr>
<tr><td rowspan="4">2</td><td>AOC-2</td><td>Naphthalene-contaminated soil</td><td>Naphthalene</td><td>None</td><td rowspan="4">Continuously sample 20 soil borings to collect geological information. Collect 1 subsurface sample from the borings every 5 feet, basing the sample interval on visual observation and field screening with an HNU. Borings will be located as follows:

- 5 borings in former creekbed
- 2 borings outside creekbed in meander
- 3 borings in naphthalene-contaminated soil area
- 5 borings in Landfill A area
- 5 borings in Landfill B area</td><td rowspan="4">Soil Analyses: TCL volatiles and semivolatiles; and TOC. 40 samples total (exclusive of QA/QC).</td></tr>
<tr><td>11</td><td>Past Landfill Area A</td><td>Maleic Acid, Phthalic Acid</td><td>None</td></tr>
<tr><td>12</td><td>Past Landfill Area B</td><td>Naphthalene</td><td>None</td></tr>
<tr><td>42</td><td>Former Creekbed</td><td>Naphthalene</td><td>Excavated materials from area had organic odors.</td></tr>
<tr><td rowspan="2">3</td><td>19, 20, 21 and 30</td><td>Dephenolizer I Area</td><td>Phenol, Acetone, Naphthalene</td><td>None. EPA suspects leaks occurred in the past.</td><td rowspan="2">Continuously sample 8 soil borings to collect geologic information. Collect 1 subsurface sample per boring, based on visual observation and field screening with an HNU. Borings would be located as follows:

- 5 borings in Dephenolizer I area
- 3 borings in Naphthalene Tank Bottoms area</td><td rowspan="2">Soil Analyses: TCL volatiles and semivolatiles; and TOC. 8 samples total (exclusive of QA/QC).</td></tr>
<tr><td>49</td><td>Naphthalene Tank Bottoms</td><td>Naphthalene</td><td>None</td></tr>
</table>

TABLE 2-1
RFI SCOPING MATRIX
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE THREE

Suggested Study Area	SWMU/ AOC No(s)	SWMU/AOC Name	Suspected Contaminants or Source	Existing Contaminant Data	RFI Phase I Approach	RFI Phase I Analytical Scheme
4	2	Existing Nonhazardous Waste Drum Storage Area	Leaking Drum Contents	None	Continuously sample 9 soil borings to collect geological information. Collect 1 subsurface sample per boring, based on visual observation and field screening with an HNU. Borings would be located as follows: - 3 borings in Existing Nonhazardous Waste Drum Storage Area - 3 borings in Past Drum Storage Facility C - 3 borings in Past Drum Storage Facility E	Soil Analyses: TCL volatiles and semivolatiles; and TOC. 9 samples total (exclusive of QA/QC).
	3	Past Drum Storage Facility C	Leaking Drum Contents	None		
	5	Past Drum Storage Facility E	Leaking Drum Contents	None		

The current existence of significant contamination in Study Areas 2, 3, and 4 has not been established. Therefore, in these areas, limited soil studies (equivalent to the Verification Investigations referred to in the USEPA Corrective Action Permit) are proposed to determine the presence or absence of contamination and to determine whether the contamination poses a threat to human health or the environment (through risk assessment). The need for further investigation (groundwater plume or source delineation) would be determined based on the Phase I RFI results. This approach can be characterized as follows:

Soil contamination confirmation sampling → Risk Assessment → Determination of need for further investigation

If no contamination posing a threat to human health or the environment is identified at one or more of the SWMUs/AOCs present in Study Areas 2, 3, or 4, Allied intends to petition for a "no further action" determination for these SWMUs/AOCs.

At the conclusion of the Phase I RFI, a report summarizing the Phase I investigation will be submitted. Results of the risk assessment will be included in this report. A work plan for the Phase II RFI will also be submitted at this time, including rationale for the Phase II scope of work or justification as to why no additional investigation is required.

2.2 STUDY AREA 1 APPROACH

Study Area 1 contains the five groundwater recovery wells (AOC-1) and the phenol water system (SWMU 46). Also, a former drum storage facility located in this area was identified in a 1937 aerial photograph. (The drums may have been empty.)

Historical data indicate that a floating layer of water-immiscible liquid, predominantly cumene, is present in this study area. Also, the presence of several volatile organic, semivolatile organic, and heavy metal compounds in the uppermost water-bearing zone is indicated.

The proposed investigation of Study Area 1 is designed to supplement previous work in this area. Data gaps for this study area were identified during RFI scoping (see Volume I of this RFI Plan). These data gaps include the following:

- Extent of the asphalt, gravel, and cement covering at the site.
- Detailed stratigraphy of the geological units.

- Degree of hydraulic interconnection, if any, between the water-bearing zones beneath the study area.
- Degree of hydraulic interconnection between groundwater and surface water.
- Groundwater flow direction, velocity, and flux, and the effects that tides, the groundwater recovery system, and sewer infiltration (if any) are having on these values.
- Withdrawal rates for each recovery well.
- Thickness of the saturated zone for each contaminated water-bearing unit.
- Depth to groundwater.
- Inventory of abandoned wells in the study area, and their closure status.
- Volume and areal extent of LNAPL.
- Nature and extent of groundwater contamination.
- Attenuation capacity and mechanisms of the soils (e.g., organic carbon content, clay content, etc.)
- Background groundwater quality.
- Potentially affected users of the water-bearing zones in the study area.
- Potentially affected users of Frankford Inlet, if any.
- Potential ecological receptors associated with Frankford Inlet.

To fill these data gaps in a cost-effective manner, a phased approach will be conducted in Study Area 1. The scope of work for the Phase I RFI for Study Area 1 is summarized in Table 2-1.

Two tasks will be conducted prior to the onset of drilling/well installation/sampling activities at Study Area 1:

- Existing monitoring-well evaluation
- Inventory of surface cover

In addition to the currently operating recovery wells, monitoring wells have been installed previously in both the Phenol Unit 2 and caustic spill areas. Of the previously installed monitoring wells, at least one well is known to exist. The existing monitoring well evaluation is required to determine which of the previously installed wells are in existence, and to determine whether they are usable for water-level measurements during the RFI. (Available well logs for these wells indicate that the installation procedures were not adequate for their use as environmental sampling wells.)

The wells will be located in the field, using available site maps; then an assessment of the physical condition of each well will be made. The following observations will be made and documented:

- Well number.
- Well security (locked/unlocked).
- Condition of well casing and protective casing (if any).
- Well casing material.
- Size of well casing.
- Depth to groundwater.
- Total depth of the well.
- Identification and depth determination of any obstructions within the well.

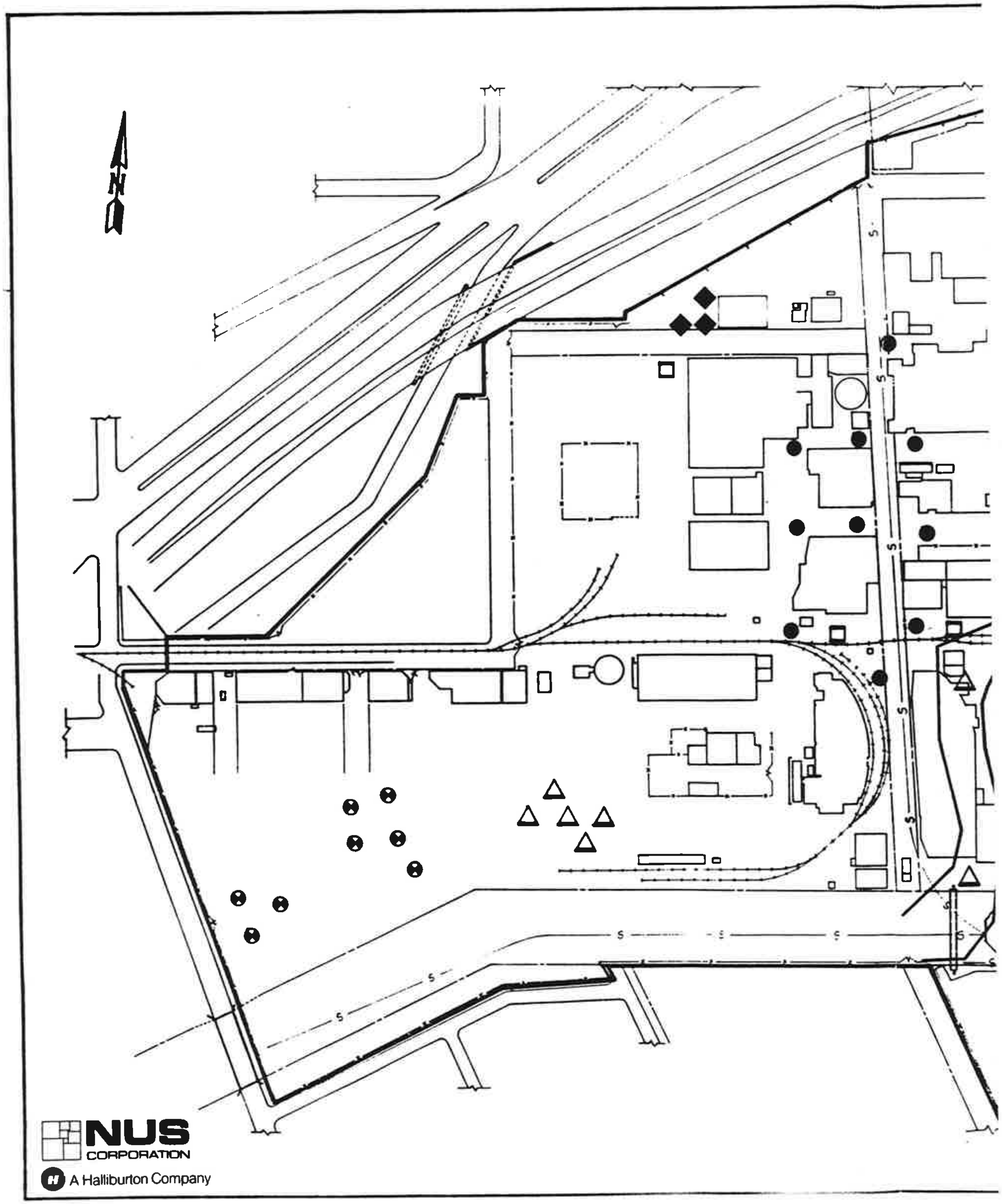
In addition to the above-listed observations, any other pertinent observations that may be identified will be noted. The observed condition of the well will be compared with the original well logs, if available. Based on the field observations and on background information available, the existing wells will be evaluated as to their potential usefulness as water-level measurement points. All usable wells will be integrated into the water-level measurement program.

During the well evaluation program, the closure status of those wells not located or determined to be unusable will also be noted.

The existing surface cover in Study Area 1 will be visually verified during Phase I. A map of the surface cover will be presented in the Phase I RFI report.

Once these preliminary activities have been completed, soil borings will be advanced in Study Area 1 to delineate the extent of the LNAPL present there. Each soil boring will be advanced and sampled continuously until the water table is encountered. Estimates of product thickness at each location will be made, based on visual observations. The soil boring program in Study Area 1 will be continued until the extent of the floating product layer is established (i.e., until no immiscible layer is encountered in the borings) in all directions. Each new soil boring location will be determined in the field, based on observations made at the previous boring location(s). An estimated 12 soil borings will be required to delineate the LNAPL areal extent. Tentative soil boring locations are presented on Figure 2-1. Soil boring procedures are described in Section 4.0.

Soil samples will be field screened visually and with an HNU. Since the makeup of the floating layer (predominantly cumene - see Section 4.0 of Volume I) has been established, no soil samples will be submitted for chemical analysis. The LNAPL areal extent and product thicknesses measured during the soil boring program will be used to estimate the volume of LNAPL present in Study Area 1.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Once the LNAPL areal extent has been established, three two-inch-diameter, stainless-steel monitoring wells will be installed to monitor the uppermost water-bearing zone. Two wells will be located southeast of the LNAPL area, whereas the third well will be located northwest of this area. Groundwater flow directions at the site have not been established. Barring man-made influences, shallow groundwater would be expected to flow to the southeast (towards the Frankford Inlet and the Delaware River). Thus, the southeast and northwest directions have been picked because they represent apparent downgradient and upgradient locations, respectively. Tentative well locations are shown on Figure 2-1. Drilling and well construction procedures for the Phase I monitoring wells are described in Section 4.0.

The rationale for installing only three monitoring wells during Phase I is that three monitoring wells are required to establish groundwater flow direction. Establishment of shallow groundwater flow direction(s) is a primary objective of the Phase I scope of work for Study Area 1. Since the man-made influences on groundwater flow (e.g., the groundwater pumping system) have not been defined, installation of more wells during Phase I could result in the installation of wells with little overall value (e.g., cross-gradient wells).

No deeper wells (e.g., wells that monitor the Farrington sand aquifer or the bedrock beneath the site) are proposed for Phase I. This decision was made, since the need for deeper monitoring wells has not been established, and data on shallow groundwater flow direction is desired beforehand to site deeper wells.

The three newly installed monitoring wells will be sampled and analyzed for those analytes shown on Table 2-1. Since samples from the newly installed wells are expected to be somewhat turbid, samples for metals analysis will be field-filtered. Dioxin in groundwater samples from these wells will be analyzed using dioxin screening method SW 8270. This is considered sufficient because the Frankford Plant did not use or produce significant quantities of chlorinated organics. Samples from each well will also be analyzed in the field for dissolved oxygen, Eh, pH, specific conductance, and temperature. These parameters serve to characterize chemical and hydrogeological characteristics of the groundwater and aquifer as well as providing information on the chemical state, toxicity, treatability, and/or fate and transport of contaminants. Details regarding sampling activities are presented in Section 4.0.

Sampling and analysis of the existing recovery wells is not proposed, since samples from these wells were recently (September 1990) analyzed using EPA methods (see Section 4.0 of Volume I of this RFI Plan). These analytical data will be validated as part of the Phase I RFI.

The new monitoring wells will be slug tested to determine the hydraulic characteristics of the water-bearing zones investigated by each well. The data generated from these tests will be used to assist definition of the water-yielding characteristics of the screened zone, to develop groundwater velocity values, and to estimate the rate of groundwater movement for the aquifer in the vicinity of the monitoring well being tested. Details on the slug test procedures are presented in Section 4.0.

A comprehensive water-level monitoring program will also be conducted as part of the aquifer testing scheme. Groundwater elevations beneath the Allied Frankford Plant are expected to vary significantly over time because of rising and falling tides in Frankford Inlet and the on-off cycling of the groundwater recovery wells. Because of this expected variation, a 7-day water level monitoring program has been developed. To supplement the monitoring well/recovery well/piezometer network, two staff gages will be placed in Frankford Inlet, one at the City of Philadelphia combined sewer outfall, and one at the southeastern edge of the Allied property.

Data from the water-level monitoring program will be used to develop overall groundwater flow directions, gradients, flow rates, and velocities. Details on this program are presented in Section 4.0.

The combination of the soil boring visual observations, water quality data, slug testing data, and water-level monitoring data will provide information to determine the areal extent and volume of LNAPL present, determine the horizontal extent of contamination, estimate loading rates to Frankford Inlet, evaluate the effectiveness of the existing pump-and-treat program in containing groundwater contamination, and assess infiltration (if any) into the city sewer system.

No investigation of the phenol water system is planned because all underground piping carrying continuous flows is being abandoned and replaced with overhead lines. An investigation of this system would not provide significant useful results. Details on the underground piping retirement program, including the program schedule, are contained in Appendix A of Volume I of this RFI Plan.

2.3 STUDY AREA 2 APPROACH

Study Area 2 is made up of the Naphthalene-Contaminated Soil area (AOC-2), Past Landfill Area A (SWMU 11), Past Landfill Area B (SWMU 12), and the Former Creekbed (SWMU 42). Naphthalene-contaminated soil was identified by Allied during the construction of a loading area at AOC-2. Soil visually observed to be contaminated was excavated and disposed off site in a secure landfill. The degree that soil contamination was removed from this area was not established, as no soil sampling was conducted during the excavation/disposal program.

Past Landfills A and B were reportedly used for the temporary storage of phthalic anhydride mother liquors during strikes in 1960 and 1966. Reportedly, the mother liquor was excavated and disposed off site once the strikes were concluded. The effectiveness of the excavation/disposal program is not documented. Also, it was reported in the RFA that tank cleanout materials, including tar acid, naphthalene, and tar base sludges, were placed in Past Landfill B. No environmental sampling has been conducted in these areas to date.

In the 1950s the Frankford Creek meander on the Allied property was filled in. The exact nature of the fill materials is unknown but may have included City of Philadelphia incinerator ash and various coal tar materials. Part of this fill was removed when a sewer line was constructed across this area. A drum storage area (the drums may have been empty) located just east of the creek meander was noted on a 1937 aerial photograph.

No environmental sampling has been conducted at this unit. Contaminant-like odors were noted during an excavation at SWMU 42 in 1986.

Because the presence of significant contamination associated with the SWMUs/AOCs making up Study Area 2 has not been established, a limited subsurface soil sampling program is proposed for this area. (The surface in this area is capped with asphalt, cement, or gravel.) This program will be roughly equivalent to the Verification Investigations cited in the USEPA RCRA Corrective Action Permit for the Allied Frankford Plant. (The USEPA has also referred to these as "verification studies" and "confirmation studies" at other sites.) The need for further investigation (groundwater plume or further source delineation) in this area will be determined based on an analysis of Phase I RFI results.

The general approach for the Study Area 2 Phase I investigation will be to advance a predetermined number of soil borings into the subsurface beneath each SWMU/AOC down to the groundwater table (or bedrock, in the unlikely event bedrock is encountered before groundwater). Soil samples will be obtained continuously throughout the drilling process, using a split-spoon sampler. Samples for chemical analysis will be collected at a frequency of once per every 5 feet of boring depth. Samples will be collected directly from the split spoon. The samples selected for chemical analysis will be based on visual observations and field screening with a photoionization detector (HNU). If no visually contaminated soil is encountered or HNU readings observed, the sample will be collected from the bottom of the sampling interval (e.g., at a depth of 5 feet or immediately above the top of the water table).

Because the exact locations of Past Landfill Areas A and B are not readily evident today (they have been covered by asphalt and gravel), five soil borings each are proposed for these areas. The excavation locations will be identified iteratively, based on observations made in previous excavations. Tentative excavation locations are shown on Figure 2-1. Since the location of AOC-2 is known, only 3 borings in this area are proposed. Five test borings are proposed for the former creekbed, since the creekbed covers a wide areal extent. Additionally, two borings outside of the creekbed are proposed to establish "baseline" soil conditions in this area.

The soil samples will be analyzed for TCL volatiles and semivolatiles; and total organic carbon (TOC). Additionally, the analytical laboratory will be instructed to look for cumene and alpha-methylstyrene (AMS) as part of their volatile analysis. TOC was selected as an analyte, as it will be used to estimate the mobility of contamination (if any) found in the soil samples. Soil samples will also be analyzed in the field for pH.

Section 3.0 provides additional details regarding proposed analyses for the soil samples obtained from each SWMU/AOC. Section 4.0 describes general drilling and sampling procedures.

2.4 STUDY AREA 3 APPROACH

Study Area 3 consists of the Dephenolizer I Area (SWMUs 19, 20, 21, and 30) and Naphthalene Tank Bottoms (SWMU 49). The Dephenolizer I Area consists of the former dephenolizer and 3 storage tanks. One of the storage tanks reportedly leaked. Drums of refined naphthalene were also stored in this area, according to a 1916 map. At SWMU 49, less than 200 cubic yards of naphthalene tank bottoms were reportedly spread upon the ground and graded during tank demolition activities. Also, drums were stored at and adjacent to SWMU 49, according to a 1937 aerial photograph. (The drums may have been empty.) No environmental sampling has been conducted at these units to date.

A limited subsurface soil sampling program is proposed for this area, since the presence of significant contamination associated with the SWMUs making up Study Area 3 has not been established. (The surface in this area is covered with gravel.) This program will be roughly equivalent to the Verification Investigation procedure cited in the Allied Frankford RCRA Corrective Action Permit. The need for further investigation (groundwater plume or further source delineation) in this area will be determined based on an analysis of Phase I RFI results. If no significant contamination is found at the units in Study Area 3, "no further action" determinations will be sought from the USEPA.

For the Study Area 3 investigation during Phase I, a predetermined number of soil borings will be advanced to the groundwater table (or bedrock, if encountered before groundwater). Soil samples will be obtained continuously using a split-spoon sampler. One sample per boring will be submitted for chemical analysis. Samples will be collected directly from the split spoon. The samples selected for chemical analysis will be based on visual observations and field screening with a photoionization detector (HNU). If no visually contaminated soil is encountered or HNU readings observed, the sample interval will be selected at the field geologist's discretion.

Because the exact location of the Dephenolizer I unit is not readily evident today (it has been dismantled and the area capped by gravel), five test borings are proposed for this area. Each new boring location will be sited in the field, based on observations made at the previous borings. Tentative boring locations are shown on Figure 2-1. Similarly, the Naphthalene Tank Bottoms area is not readily evident today; this area is currently covered by gravel. However, since the general location is known and the areal extent of the unit is relatively small, only three excavations are proposed for this unit.

The soil samples will be analyzed for TCL volatiles and semivolatiles, as well as TOC and pH (field analysis). Additionally, the analytical laboratory will look for cumene and AMS during the volatile analysis. The rationale for the TOC analysis is the same as stated above for Study Area 2.

Additional details regarding the proposed analyses for the soil samples obtained from Study Area 3 during Phase I are provided in Section 3.0. The general drilling and sampling procedures for the test borings are presented in Section 4.0.

2.5 STUDY AREA 4 APPROACH

Study Area 4 consists of the Existing Nonhazardous Waste Drum Storage Area (SWMU 2), Past Drum Storage Facility C (SWMU 3), and Past Drum Storage Facility E (SWMU 5). Drummed wastes were stored in the open in these units, on top of a paved or graveled surface. No known releases from these units have occurred. No environmental samples have been collected at these units to date.

Since no known contamination associated with Study Area 4 has been identified, a limited subsurface soil sampling program for this area is proposed. (The surface in this area is partially covered with asphalt and partially covered with gravel.) This program will be roughly equivalent to the Verification Investigation procedure cited in the Allied Frankford RCRA Corrective Action Permit. The need for further investigation (groundwater plume or further source delineation) in this area will be determined based on an analysis of Phase I RFI results. If no significant contamination is found at the units in Study Area 4, "no further action" determinations from the USEPA will be sought.

In Study Area 4, the Phase I RFI program will consist of a predetermined number of soil borings being advanced to the groundwater table (or bedrock, if encountered first). Soil samples will be obtained continuously using a split-spoon sampler. One sample per boring will be collected for chemical analysis. Samples will be collected directly from the split spoon. The samples selected for chemical analysis will be based on visual observations and field screening with an HNU. If no unusual intervals are encountered, the sample interval will be selected at the field geologist's discretion.

For the Phase I RFI, three test borings are proposed per drum storage area . The boring locations will be determined in the field, based on observations made in previous borings.

The soil samples will be analyzed for TCL volatiles and semivolatiles; pH (field analysis); and TOC. Additionally, the analytical laboratory will look for cumene and AMS during the volatile analysis. The rationale for the TOC analysis is the same as stated above for Study Area 2.

Section 3.0 provides details regarding the proposed analyses for the soil samples obtained from Study Area 4. The general excavation and sampling procedures for the test borings are presented in Section 4.0.

3.0 QUALITY ASSURANCE OBJECTIVES

The RFI objectives are summarized in Section 2.0. Additional site data are required to meet these objectives. The data collection and quality assurance requirements described in this document are intended to provide data that are adequate in both number and quality to support completion of the first phase of the RFI.

3.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the RFI activities. The intended use of the data must be defined to develop site-specific DQOs. This use must be balanced between data quality needs and schedule as well as budget constraints.

Specific analytical protocols are selected to meet the DQOs in the following ways:

- Compare regulatory requirements, risk-based criteria, and data needs for risk assessment or engineering purposes to the detection limits for available analytical methods.

- Select analytical methods to allow quantification of the analytes at levels sufficiently below the relevant criteria to minimize the number of critical data points.

- Evaluate the maximum allowable variability in the data based on the relevant criteria comparison.

- Develop site-specific acceptable variability based on the intended data use and method-specific precision and accuracy information.

Table 3-1 presents a summary of the proposed Phase I sampling and analysis program for the Allied Fibers Frankford RFI. The information in this table was developed to meet the RFI objectives.

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

Matrix	Analysis	Data Use (A)	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Equipment (Rinsate) Blanks (C)	Field Blank (E)	Trip Blank (F)
STUDY AREA 1										
Groundwater	TCL Volatiles (G) Semivolatiles, and Pesticide/PCBs	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	3	1	1	1	1
	TAL Metals	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	3 (D)	1 (D)	1 (D)	1	0
	Organophosphorus Pesticides	1,2,3,4	Per Method	SW-8140	Laboratory	3	1	1	1	0
	Herbicides	1,2,3,4	Per Method	SW-8150	Laboratory	3	1	1	1	0
	Dioxin Screen	1,2,3,4	Per Method	SW-8270	Laboratory	3	1	1	1	0
	TOC	1,5	Per Method	SW 9060	Laboratory	3	1	1	1	0
	pH	1,5	NA	NA	Field	3	0	0	0	0
	Specific Conductance	1,5	NA	NA	Field	3	0	0	0	0
	Temperature	1,5	NA	NA	Field	3	0	0	0	0
	Oxidation-Reduction Potential (Eh)	1,5	NA	NA	Field	3	0	0	0	0
	Dissolved Oxygen	1,5	NA	NA	Field	3	0	0	0	0
STUDY AREA 2										
Soil	TCL Volatile Organics (G)	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	40	2	2	2	10
	TCL BNA Extractables	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	40	2	2	2	0
	TOC	1, 5	Per Method	SW 9060	Laboratory	40	2	0	0	0
	pH	1,5	NA	NA	Field	40	0	0	0	0

TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE TWO

Matrix	Analysis	Data Use (A)	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Equipment (Rinsate) Blanks (C)	Field Blank (E)	Trip Blank (F)
STUDY AREA 3										
Soil	TCL Volatile Organics (G)	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	8	1	1	1	4
	TCL BNA Extractables	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	8	1	1	1	0
	TOC	1, 5	Per Method	SW 9060	Laboratory	8	1	0	0	0
	pH	1,5	NA	NA	Field	8	0	0	0	0
STUDY AREA 4										
Soil	TCL Volatile Organics (G)	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	9	1	1	1	4
	TCL BNA Extractables	1,2,3,4	Per Method	CLP SOW 3/90	Laboratory	9	1	1	1	0
	TOC	1,5	Per Method	SW 9060	Laboratory	9	1	0	0	0
	pH	1,5	NA	NA	Field	9	0	0	0	0

TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE THREE

(A) 1 - Site Characterization
2 - Risk Assessment
3 - Evaluation of Alternatives
4 - Engineering Design of Alternatives
5 - Input for Contaminant Transport Evaluation

(B) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample).

(C) Equipment Blank - Sample obtained by pouring analyte-free, deionized water through sample collection equipment (e.g., bailer) before use. Assesses the effectiveness of decontamination procedure.

(D) Filtered samples only for metals analysis.

(E) Field Blank - Generated at time of sampling by filling bottles in the field with analyte-free, deionized water.

(F) Trip Blank - Trip blanks are prepared prior to the sampling event in the actual sample containers and are kept with the investigation samples throughout the sampling event. Trip blanks must be submitted with each batch of samples submitted for VOA analysis. They are used to monitor the loss (or gain) in the VOA fraction associated with routine sample handling.

(G) In addition to TCL VOAs, alpha-methyl styrene and cumene need to be quantified.

CLP Contract Laboratory Program
NA Not Applicable.
SW Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.

BNA - Base/Neutral/Acid

Note: Allied reserves the right to collect additional quality control samples beyond those shown on this table.

3.2 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPLETENESS, AND COMPARABILITY (PARCC) GOALS

The quality of a data set is measured by certain characteristics of the data, namely the PARCC parameters. Some of the parameters are expressed quantitatively, whereas others are expressed qualitatively. The objectives of the RFI and the intended use of the data define the PARCC goals.

3.2.1 Precision and Accuracy

Precision and accuracy characterize the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is expressed as a range (the difference between two measurements of the same parameter) or as a relative percent difference (the range relative to the mean, expressed as a percent). Range and Relative Percent Difference (RPD) values are calculated as follows:

$$\text{Range} = OR - DR$$

$$\text{and} \qquad RPD = \frac{OR - DR}{1/2\,(OR + DR)} x\ 100\%$$

where:

OR = original sample result

DR = duplicate sample result

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a quality assurance check.

Accuracy is the comparison between experimental and known or calculated values expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (standard recovery) or into actual samples (matrix spike or surrogate spike recovery). Recovery is calculated as follows:

$$\%R = \frac{E}{T} \times 100\%$$

where:

E = Experimental result

T = True value or theoretical result

with $$\text{Theoretical result} = \frac{(\text{Sample aliq.})(\text{Sample conc.}) + (\text{Spike aliq.})(\text{Spike conc.})}{(\text{Sample aliquot} + \text{Spike aliquot})}$$

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series of %R values. Organic %R values are set at the mean plus or minus two times the standard deviation.

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples. Such criteria are used in risk assessment and screening of remedial alternatives. Given the uncertainties associated with field work and laboratory activity, the following overall precision and accuracy goals are identified to meet the project objectives:

- Precision: ± 50 percent RPD
- Accuracy: ± 50 percent recovery

Analytical precision and accuracy will be evaluated upon receipt of the laboratory data. Analytical precision will be measured as the relative standard deviation of the data from the laboratory (internal) duplicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and surrogate spike samples. The requirements in Table 3-2 will be used for the organic analyses.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate NUS Standard Operating Procedures (SOPs, see Appendix A), precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field and equipment) will be used to estimate field sampling and accuracy.

No project resources will be expended to develop precision and accuracy data for method (field or analytical) validation except those commonly applied for collection of routine QA/QC data. Routine

TABLE 3-2

SURROGATE SPIKE AND MATRIX SPIKE PERCENT RECOVERY LIMITS
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
(% RECOVERY)

SURROGATE SPIKE RECOVERY LIMITS

Fraction	Surrogate Compounds	Water	Low/Medium Soil
VOA	Toluene-d_8	88-110	84-138
VOA	4-Bromofluorobenzene	86-115	59-113
VOA	1,2-Dichloroethane-d_4	76-114	70-121
Acid	Phenol-d_5	10-110	24-113
Acid	2-Fluorophenol	21-110	25-121
Acid	2,4,6-Tribromophenol	10-123	19-122
Base/Neutral	Nitrobenzene-d_5	35-114	23-120
Base/Neutral	2-Fluorobiphenyl	43-116	30-115
Base/Neutral	p-Terphenyl-d_{14}	33-141	18-137

MATRIX SPIKE RECOVERY LIMITS

Fraction	Matrix Spike Compounds	Water	Soil/Sediment
VOA	1,1-Dichloroethene	61-145	59-172
VOA	Trichloroethene	71-120	62-137
VOA	Chlorobenzene	75-130	60-133
VOA	Toluene	76-125	59-139
VOA	Benzene	76-127	66-142
Acid	Pentachlorophenol	9-103	17-109
Acid	Phenol	12-110	26-90
Acid	2-Chlorophenol	27-123	25-102
Acid	4-Chloro-3-methylphenol	23-97	26-103
Acid	4-Nitrophenol	10-80	11-114

TABLE 3-2
SURROGATE SPIKE AND MATRIX SPIKE PERCENT RECOVERY LIMITS
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE TWO

MATRIX SPIKE RECOVERY LIMITS (continued)

Fraction	Matrix Spike Compounds	Water	Soil/Sediment
Base/Neutral	1,2,4-Trichlorobenzene	39-98	38-107
Base/Neutral	Acenaphthene	46-118	31-137
Base/Neutral	2-4 Dinitrotoluene	24-96	28-89
Base/Neutral	Pyrene	26-127	35-142
Base/Neutral	N-Nitroso-Di-n-Propylamine	41-116	41-126
Base/Neutral	1,4-Dichlorobenzene	36-97	28-104
Pesticides	Lindane	56-123	46-127
Pesticides	Heptachlor	40-131	35-130
Pesticides	Aldrin	40-120	34-122
Pesticides	Dieldrin	52-126	31-134
Pesticides	Endrin	56-121	42-139
Pesticides	4,4'-DDT	38-127	23-134

QA/QC data will include analyses from field duplicates and equipment rinsate blanks based on the existing guidance that specifies the type and proportion of samples submitted for QA/QC (EPA, 1987).

Validity of data (i.e., 95-percent confidence limit) with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols outlined in the USEPA's National Functional Guidelines for Validating Data. In general, results that are rejected by the validation process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

3.2.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the material being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data. Sample collection, preservation, and storage are discussed in Sections 4.1 and 5.0 of this document. Section 2.0 of this document contains details on the site sampling program and the rationale for sampling locations. The sampling program is designed to ensure that the data obtained during the RFI accurately represent the site conditions.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 4.3 of this document. To ensure that the data are representative, NUS' Standard Operating Procedures (see Appendix A) will be used.

To ensure that sample aliquots to be analyzed are representative, samples (except volatile aliquots) will be homogenized in the laboratory by removing non-representative materials (e.g., sticks and stones), then stirring, shaking, crushing, and/or blending the sample as appropriate to the matrix.

3.2.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100-percent completeness is expected. However, as matrix complexity and heterogenicity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from sacrificing attainment of the RFI objectives. Each medium is critical to the site assessment. Consequently, there exists some critical data requirement below which the objectives of the study will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location (e.g., downgradient monitoring wells) or by analysis. If in the evaluation of laboratory results it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis, resampling of the deficient data points will be necessary.

3.2.4 Comparability

One of the objectives of this Sampling and Analysis Plan is to provide analytical data of comparable quality both between sample locations and with data from previous investigations. Both the analytical procedures and sample collection techniques (as defined in NUS SOPs) specified herein will maximize the comparability of the RI data within this investigation and to any previous investigation. Additionally, to enhance comparability between samples, consideration will be given to seasonal conditions, stream flow, or other environmental conditions that could influence the analytical results.

modified to obtain sufficient soil for chemical analysis by using a 3-inch outside diameter, split-barrel sampler driven with a 300-pound hammer.

Each soil sample collected for lithologic description will be placed in an 8-ounce jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded (i.e., project, boring and sample numbers, depth, blow counts, and date) by the field geologist. Samples obtained for chemical analysis will be placed in the appropriate laboratory-cleaned containers (supplied by the laboratory). The driller shall prepare a separate written boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities.

A complete log of each well boring will be maintained by NUS in accordance with NUS SOP GH-1.5 (see Appendix A). Appendix B contains an example of the boring description form (log) .

At a minimum, the boring log will contain the following information, when applicable, for each overburden well boring:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA/HNU readings (if taken), drilling methods, and total depth of each borehole should be included on each log, as well as any other pertinent observations. Sample bottles containing soil samples for lithologic description will be consecutively numbered starting with S-1. In addition, the following information shall be recorded on the lid of these sample jars:

- Job name and number
- Well number and sample number
- Date
- Depth of sample
- Blow counts

4.2.4 Monitoring Well Construction/Installation

For the Phase I RFI, monitoring well installation is proposed only for Study Area 1. Since LNAPL (cumene) is known to exist in this area, Study Area 1 monitoring wells will be constructed of 2-inch-diameter, flush-joint-threaded, stainless-steel casing and well screens equipped with an end plug. Figure 4-1 illustrates typical well construction details for the monitoring wells.

Well screens will be 10 feet in length. The slot size will be determined in the field, but will be no larger than 0.02 inches. Placement depths of well screens will be determined in the field based on drilling observations and the anticipated groundwater-level fluctuations. The screens will be installed to monitor the top of the water table.

The stainless-steel well installation procedure will consist of backfilling the boring (if required) with a sand/bentonite mix to a depth of approximately 1/2 to 1 foot below the desired depth for the bottom of the well screen. The stainless-steel riser and screen will be placed at the desired depth in the completed boring. The annulus of the boring around the well screen, and 1 to 3 feet above the well screen, will be backfilled with clean silica sand (Nos. 20 to 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal (minimum 2-foot thickness) will then be installed and allowed to hydrate; the remainder of the annulus of the boring (from the seal to ground surface) will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless-steel or plastic tape.

Protective steel casings equipped with locking steel caps will be installed around all wells and piezometers. In addition, a cement apron will be built up around the casing to prevent ponding of water around the well. All locks supplied for the wells will be keyed alike. After installation, the ground surface, the top of the riser pipe, and the top of the protective casing will be surveyed to within 0.01-foot vertical accuracy. In addition, the well will be surveyed to a 0.1-foot horizontal accuracy.

A monitoring well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix B.

4.2.4.1 Well Development

All newly installed monitoring wells will be developed after installation to remove fines and sediments from around the well screens and to remove drill cuttings and residual drilling fluids from

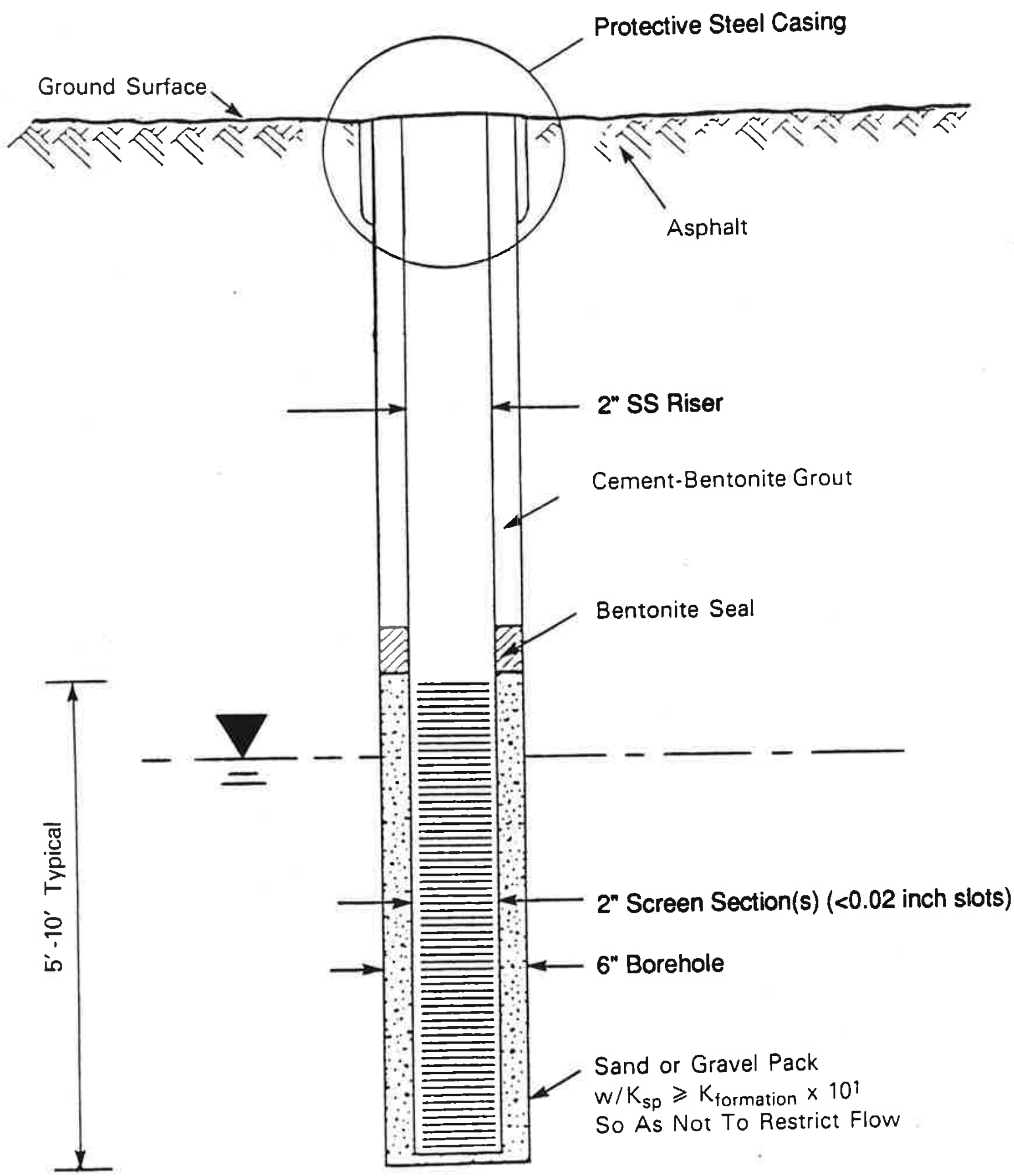


FIGURE 4-1
TYPICAL SHALLOW MONITORING WELL INSTALLATION

ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

NUS CORPORATION
A Halliburton Company

the area around the monitored interval of the boring. If existing usable piezometers are identified during the RFI, they will also be developed, if necessary. Wells will be developed by air lift, bailing and surging, or pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist. Development water will be handled according to procedures outlined in Section 4.2.8.

4.2.4.2 Procedures for Aquifer Testing

Monitoring wells will be used for aquifer testing to determine the groundwater flow conditions in the water-bearing zones investigated by each well. The data generated from these tests will be used to assess the water-yielding characteristics of each formation, develop groundwater velocity values, and estimate the rate of groundwater movement for the aquifers in the vicinity of the monitoring wells that are tested.

In-situ hydraulic conductivity testing (slug tests) will be performed in the newly installed monitoring wells. Procedures for performing these slug tests will be in accordance with Section 5.1 of NUS SOP GH-2.4. Pressure transducers and data loggers will be used for data collection, where appropriate, to obtain sufficiently accurate field data. At a minimum, the following information will be collected (when applicable) for each well during the performance of aquifer tests:

- Well number/depth/screened interval/inside diameter of screen/diameter of sand pack
- Static water level
- Method of inducing water-level change
- Time/recovery data
- Total time of test

Data generated by the tests will be documented on the appropriate data sheets and analyzed according to Section 5.3 of NUS SOP GH-2.4, using the most appropriate evaluation technique for the existing hydrologic conditions. A sample data sheet is provided in Appendix B.

4.2.4.3 Water-Level Monitoring

Groundwater elevations (and flow directions) beneath portions of the Allied facility are expected to vary temporally, because of rising and falling tides in Frankford Inlet and the on-off cycling of the groundwater recovery wells. Because of this expected variation, a 7-day water-level monitoring program has been devised. Data developed from this program will be used to develop overall groundwater flow directions, gradients, flow rates, and velocities.

Simultaneous water-level measurements shall be obtained by installing IN SITU® type, pressure-sensitive transducers in monitoring wells, recovery wells, and one staff gage location in the inlet. All measurements shall be taken in reference to the top of the well or staff gage, that will be later surveyed for vertical control. The transducers shall be connected to a HERMIT SE 2000 or HERMIT SE 1000 B Hydrologic Monitor that will record water-level measurements over time. Transducers shall be installed in a minimum of two recovery (pumping) wells, two monitoring wells, and at one staff gage location. The specific wells to be monitored shall be determined by the field geologist, based on site conditions. The well locations selected for monitoring should meet the following criteria:

- Provide adequate coverage across the property
- Provide water level data at a well location that is near the inlet
- Provide water level data at a well location that is distant from the inlet
- Provide water level data at maximum drawdown pumping wells

The water-level measurements shall be recorded at a minimum of 1-hour intervals over an entire duration of 7 days. In addition, initial water-level measurements shall be collected manually in all the wells located on the property and at the two staff gage locations on the inlet prior to the installation of the transducers, as well as at selected intervals during the 7-day test. Manual measurements will be taken with an M-scope (electrical water-level indicator), steel tape and chalk, or popper, using the top of the riser pipe as the reference point for determining depths to water for the wells and piezometers. Water-level measurements will be recorded to the nearest 0.01 foot in the appropriate field log book. The measuring device will be decontaminated between wells by cleaning the portion of the device that comes into contact with liquid in the monitoring well with deionized water.

Prior to the 7-day measurement, groundwater pumping rates will be determined, using either flow meters (if available) or manual methods. (Pumping durations will be determined during the test by analyzing the transducer data from the recovery wells.) If functioning flow meters are not available, then field measurements shall be taken to collect the data. The measurements shall consist of estimating pumping volume over time with a calibrated container and a stopwatch, or by using other comparable methods as determined to be appropriate by the field geologist.

The resultant transducer data shall be converted to elevations and plotted on hydrographs. Comparison of hydrographs in the wells with the hydrograph of the inlet shall be used to determine the amount of time that groundwater flows toward and discharges into the inlet versus the time that the inlet recharges groundwater. The hydrographs can also be used to evaluate changes in the groundwater flow gradients and their relationship to changes in drawdown of the pumping wells and tidal fluctuations in the inlet.

The manual water-level measurements collected and the water transducer data shall both be converted to elevations. The water-level elevations at a specific time and date shall be plotted on a base map for developing potentiometric surface contours. The potentiometric surface contour maps will be used to determine both groundwater flow directions and gradients.

4.2.5 Staff Gages

Two staff gages will be placed in Frankford Inlet adjacent to the site. One staff gage shall consist of a reference point marked on the bridge leading to the south tank farm. The second gage will be located in the inlet on the Bridge Street bridge near the southeastern corner of the Allied property. The top of the staffs should be at least 1 foot above the known maximum water level. A horizontal black line shall be placed on an orange background near the top of the staff gage, indicating the reference point elevation for measuring the static water level of the surface-water body.

4.2.6 Surveying

Surveying services will include the surveying of horizontal locations and vertical elevations of newly installed monitoring wells, existing piezometers (if any), and staff gages. Vertical elevation shall be surveyed to an accuracy within 0.01 feet and within 0.1 feet for horizontal locations.

The ground elevation, the top of the protective casing, and the top of the uncapped riser pipe of the newly installed monitoring wells and piezometers shall be surveyed with respect to horizontal locations and vertical elevations. Each point of measurement shall be marked using a heavy, black indelible ink marker.

The staff gages will contain an inscribed permanent marking, which will serve as the point of measurement. Thus, the horizontal location and vertical elevation to this point of measurement shall be surveyed for the staff gages.

Soil boring locations will also be surveyed. Horizontal location accuracy shall be within 0.1 foot, whereas vertical elevations (of the ground surface) will be established within 0.01 foot.

4.2.7 Reporting

The following reports and documentation will be the responsibility of the field geologist during the drilling activities. Copies of applicable forms that will be used by the site geologist are located in Appendix B.

Site Logbook - See NUS SOP SA-6.3.
Daily Activities Record-Field Investigation Report - See Appendix B.
Boring Log - See Appendix B.
Overburden Monitoring Well Sheet - See Appendix B.
Data Sheet for Slug Test - See Appendix B.
Groundwater Level Measurement Sheet - See Appendix B.

The field geologist's notebook shall contain information about the drilling activities such as start/finish times, standby times, and problems or changes encountered during excavation. Drilling and monitoring well construction information (e.g., footage drilled, depth of casing, etc.) will be recorded daily on the boring log and the overburden monitoring well sheet, as appropriate. The boring logs, along with the geologist's notebook, will be used to prepare the Daily Activities Record - Field Investigation Report. This report will identify drilling activity and quantities of material used on a daily basis, and shall be signed by the drilling subcontractor foreman (or equivalent) and the site geologist. The reports shall be submitted to the Project Manager at the completion of each week. These reports will also be used to fill out the site logbook.

4.2.8 Investigation Waste Disposal

Drill cuttings will be collected and disposed of by Allied as hazardous or nonhazardous waste, as appropriate. Decontamination water, monitoring well development water, and purge water will be collected for treatment on site using Allied's wastewater collection and pretreatment system.

4.3 GENERAL SAMPLING OPERATIONS

4.3.1 Subsurface Soil Sampling

This soil sampling plan was developed to investigate the subsoil beneath the 12 SWMUs and 2 AOCs. A total of forty-nine borings will be drilled and sampled at various locations throughout these units, as discussed in Section 2.0.

Soil samples will be collected for chemical analysis during the drilling activities using split-spoon samples, as discussed in Section 4.2.2.1. Samples will be collected continuously, or as determined by the site geologist. Procedures for obtaining the soil sample from the split spoon will be in accordance with NUS SOP GH-1.3, Section 5 (Appendix A). All pertinent field data, including soil pH, shall be recorded using Attachment B-8 of NUS SOP SA-6.1 (Sample Log Sheet in Appendix B) and the field notebook.

4.3.2 Groundwater Sampling

One round of groundwater sampling will be conducted for the three newly installed monitoring wells. The proposed analytes for the groundwater samples are specified in Table 3-1.

Groundwater samples will be collected in accordance with NUS SOP SA-1.1, Section 5. Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated stainless-steel bailer or a suction pump. Three to five well volumes will be purged. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 70 percent; then a sample will be collected. In the event that recovery is slow, samples will be collected the following day. Field measurements, including pH, Eh, dissolved oxygen, temperature, and specific conductance, will be taken at the beginning, middle, and end of purging, according to SF-1.1 (Section 5.0). Filtered samples will be obtained for metals analysis. Filtering and preservation of samples shall be conducted in accordance with SF-1.2 (Section 5.2.5).

Dedicated stainless-steel bailers will be used for sample collection. With the exception of the metals, samples will be poured directly from the bailer into the appropriate sample bottles for analysis.

All pertinent field data shall be recorded using Attachment B-7 of SA-6.4 (Sample Log Sheet in Appendix B) and the field notebook.

4.4 SAMPLE ANALYSIS

Samples collected at the Allied facility will be submitted for the laboratory analyses presented in Table 3-1. This table indicates the analytical parameters and analytical methods for each sample. Table 4-1 summarizes the analyses, bottle requirements, preservation requirements, and holding times for each sample.

4.5 DECONTAMINATION PROCEDURES

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. Such equipment includes drilling rigs, downhole tools, augers, pumps, well casing and screens, soil and water sampling equipment, and water-level measurement devices.

4.5.1 Major Equipment Decontamination

All drilling equipment, including the drill rig and its transport system, shall be steam-cleaned as follows: prior to beginning work, between the drilling of separate boreholes, any time the drilling rig leaves the drill site prior to completing a boring, and at the conclusion of the drilling program.

Decontamination operations will consist of washing equipment using a high-pressure steam wash. All decontamination activities will take place on the existing Allied facility tanker truck wash apron. Additional requirements for drilling equipment decontamination can be found in NUS SOP GH-1.6, Section 5.

4.5.2 Sampling Equipment Decontamination

All sampling equipment used for collecting samples for chemical analysis shall be decontaminated both prior to sampling in the field and between samples in accordance with Section 5 of NUS SOP SF-2.3. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Methanol rinse
- Distilled/deionized water rinse
- Air dry

Field analytical equipment, such as instrument probes, will be rinsed with distilled/deionized water.

4.5.3 Personnel Decontamination

Personnel decontamination is discussed in the Health and Safety Plan (Section 2.0 of Volume 3 of this RFI Plan).

4.0 FIELD INVESTIGATION ACTIVITIES

This section in general describes the guidelines and procedures to be implemented during the various activities involved in performing this field investigation for Allied Fibers. The following items are discussed:

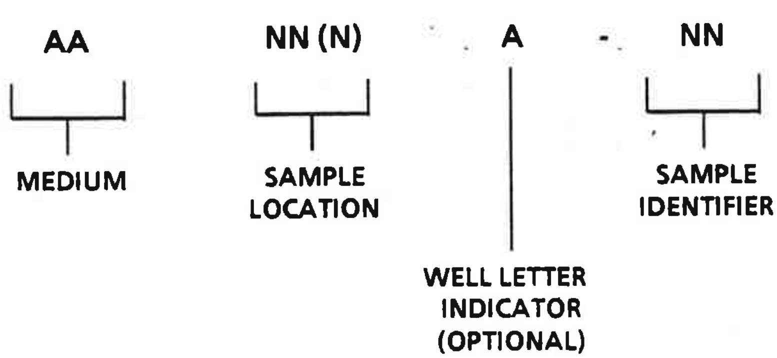
- General Field Guidelines
- General Field Operations
- General Sampling Operations
- Sample Analysis
- Decontamination Procedures

4.1 GENERAL FIELD GUIDELINES

4.1.1 Sample Identification System

Each sample taken for the Allied Fibers Frankford Plant RFI will be assigned a unique sample tracking number. The sample tracking number will consist of a three-segment, alpha-numeric code that identifies the sample medium, location, and the sample depth (in the case of soil samples) or the sampling event (in the case of monitoring well samples). Any other pertinent information regarding sample identification will be recorded in the field logbooks.

The alpha-numeric coding to be used in the sample numbering system is explained in the following diagram and the subsequent definitions:



A groundwater sample collected during round 2 from a shallow well installed adjacent to MW-102 during Phase 2 of sampling would be:

MW102B - 02

A groundwater sample collected during round 2 from a medium-depth well installed adjacent to MW-102 would be MW202-02.

A subsurface soil sample taken from Boring No. 7 at a depth of 8 to 9.5 feet would be:

SO07 - 08

All quality control (QC) samples will be coded as field samples in order not to identify the QC sample to the laboratory. QC samples will be noted in the field log. For example, a duplicate of sample SO07-08 could be designated SO07-09. Information regarding sample labels to be attached before shipment to a laboratory is contained in Section 5.2 of NUS SOP SA-6.1 (see Appendix A). Appendix B contains an example of the sample label and chain-of-custody seal for use in Region III.

4.1.2 Sample Handling

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and the analyses requested. The EPA User's Guide to the Contract Laboratory Program (CLP) (EPA, 1986a), the October 26, 1984 Federal Register (49 FR 43260), and the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986b) address the topics of containers and sample preservation. Table 4-1 provides a site-specific summary of all sample handling considerations.

4.1.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with NUS SOPs SA-6.2 and 6.6 (see Appendix A), which are in accordance with the EPA User's Guide to the Contract Laboratory Program (EPA, 1986a). The Field Operations Leader will be responsible for contacting the laboratory representative for each shipment and will report the following:

- Sampler name and telephone number.
- Site name/code.
- Number(s), matrix(ces), and concentration(s) of samples shipped.

TABLE 4-1

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

Media	Analysis	Number of Samples	No. of Containers per Sample(1)	Type of Container	Preservation Requirements	Holding Time(2)
STUDY AREA 1						
Groundwater	Volatile Organics	7	3	40-ml VOA vials	HCl to pH<2 Cool to 4° C	14 days
	BNA extractables, Pesticides/PCBs, Herbicides, Organophosphorus Pesticides	6	8	1-liter amber glass bottles	Cool to 4° C	7 days until extraction, 40 days after extraction
	Dioxin Screen	6	2	1-liter amber glass bottles	Cool to 4° C	7 days until extraction, 40 days after extraction
	Metals (filtered)	6	1	1-liter polyethylene bottle	HNO_3 to pH<2 Cool to 4° C	6 months; Hg - 28 days
	TOC	6	1	500- ml polyethylene bottle	H_2SO_4 or HCl to pH<2 Cool to 4° C	28 days
STUDY AREA 2						
Soil	Volatile Organics	56	3	4 ounce, wide-mouth glass jar	Cool to 4° C	7 days
	BNA Extractables	46	1	8-ounce, wide-mouth glass jar	Cool to 4° C	7 days until extraction, 40 days after extraction
	TOC	42	1	8-ounce, wide-mouth glass jar	Cool to 4° C	28 days

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA
PAGE TWO

Media	Analysis	Number of Samples	No. of Containers per Sample	Type of Container	Preservation Requirements	Holding Time
STUDY AREA 3						
Soil	Volatile Organics	15	3	4 ounce, wide-mouth glass jar	Cool to 4° C	7 days
	BNA Extractables	11	1	8-ounce, wide-mouth glass jar	Cool to 4° C	7 days until extraction, 40 days after extraction
	TOC	9	1	8-ounce, wide-mouth glass jar	Cool to 4° C	28 days
STUDY AREA 4						
Soil	Volatile Organics	16	3	4-ounce, wide-mouth glass jar	Cool to 4° C	7 days
	BNA Extractables	12	1	8-ounce, wide-mouth glass jar	Cool to 4° C	7 days until extraction, 40 days after extraction
	TOC	10	1	4-ounce, wide-mouth glass jar	Cool to 4° C	28 days

(1) Additional containers will be required for matrix spike/matrix spike duplicate samples.
(2) Holding times shown are from the date of sample collection.

- Carrier name and air bill number(s) for the shipment.
- Method of shipment (e.g., overnight, 2-day).
- Date of shipment.
- Suspected hazards associated with the samples or site.

4.1.4 Documentation

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the mobilization of sample containers and contaminant-free water. Section 5.3 of NUS SOP SA-6.1 (see Appendix A) provides a description of the chain-of-custody procedures to be followed. An example of the chain-of-custody record is included in Appendix B.

In addition, a sample log sheet will be completed for each sample collected. This form will contain the sample description and will document time and date, location, field measurements, and other pertinent data relative to the various samples. One form is specifically used for soil (and sediment) samples; another form is used for groundwater samples. An example of these forms can be found in NUS SOP SA-6.6 (see Appendix B).

Separate bound/weatherproof field notebooks shall be maintained by each sampling event leader and the site safety officer (SSO). The Field Operations Leader (FOL), sampling event leader (or designee), and SSO shall record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, description of photographs, etc.

A site logbook shall be maintained by the Field Operations Leader (FOL). The requirements of the site logbook are outlined in NUS SOP SA-6.3, Sections 5 and 7. This book will contain a summary of the day's activities and will reference the field notebook(s), when applicable.

Each supervisor of a drilling subcontractor activity must complete a Daily Activities Record Field Investigation Report. The Daily Activities Record Field Investigation Report documents the activities and progress of the daily drilling activities. The information contained within this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and material used. An example of this form is provided in Appendix B.

At the completion of field activities, the FOL shall submit to the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc. The Project Manager shall ensure that these materials are entered into the NUS document control system in accordance with appropriate administrative guidelines.

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The FOL notifies the Project Manager of the need for the change.
- If necessary, the Project Manager will discuss the change with the pertinent individuals (e.g., Allied Fibers Project Manager) and will provide a verbal approval or denial to the FOL for the proposed change.
- The FOL will document the change on a Task Modification Request form (see Appendix B) and forward the form to the NUS Project Manager at the earliest convenient time (e.g., end of the work week).
- The NUS Project Manager will sign the form and distribute copies to the Allied Fibers Project Manager, Quality Assurance Officer, Field Operations Leader, and the project file.
- A copy of the completed Task Modification Request form will also be attached to the field copy of the affected document (i.e., this Sampling and Analysis Plan).

4.2 GENERAL FIELD OPERATIONS

4.2.1 Mobilization/Demobilization

Following approval of the RFI Plan, NUS will begin mobilization activities. All field team members will review the RFI Plan, including the project-specific Health and Safety Plan (HASP). In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the RFI field activities.

Equipment mobilization may include, but will not be limited to, the mobilization and set-up of the following equipment:

- Sampling equipment.
- Hydrogeologic monitoring equipment.

- Health, safety, and decontamination equipment.
- Subcontractor equipment.

The Field Operations Leader (FOL) will coordinate the mobilization activities. The FOL will also make any necessary equipment purchases to conduct the field investigation. The equipment for sampling; for hydrogeologic monitoring; and for health, safety, and decontamination activities will be mobilized from Gaithersburg. After field activities are completed, NUS personnel will demobilize the equipment back to Gaithersburg.

The subcontractor who is awarded the subcontract to perform the drilling will begin to mobilize equipment immediately after receiving notice to proceed. The subcontractor will be responsible for mobilizing and demobilizing the necessary equipment to perform the work outlined in the bid specifications.

4.2.2 Existing Well Evaluation

Allied Frankford files indicate that monitoring wells have been constructed in the Phenol Unit 2 and caustic spill areas in the past. Only one of these wells is known to exist. A program to determine their existence and to evaluate their usefulness as water-level measurement points during the Phase I RFI will be conducted. (Available logs for these wells indicate the installation procedures were not adequate for their use as environmental sampling wells.) This evaluation will be conducted in accordance with the NUS SOP GH-1.2 (see Appendix A). This first step in evaluating the existing wells will be to review existing Allied files to determine the number and locations of wells that have been constructed, and to study the work plan(s) for their installation (if available). Information to be evaluated includes the rationale for well placement and length of the monitored interval; and drilling and well construction technologies. Once locations for these past wells have been established, they will be inspected to determine whether the wells are present today. If so, the following features will be noted:

- Well number.
- Well security (locked/unlocked).
- Condition of well casing and protective casing (if any).
- Presence of depressions or standing water around the casing.
- Well casing material.
- Size of well casing.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.

- Presence of sediment in the well.
- Depth to groundwater.
- Total depth of the well.
- Identification and depth determination of any obstructions within the well.

A record of all field procedures, tests, and observations will be recorded in a field notebook. Annotated sketches will be drawn, if appropriate.

4.2.3 Drilling Operations

4.2.3.1 Overburden Drilling Procedures

Drilling operations for monitoring well and soil borings will be conducted in accordance with NUS SOP GH-1.4 (see Appendix A), using any combination of drilling methods needed to drill through the sediments; with the only restriction being that potable water is the only fluid allowed if one is required. The preferred methods used to advance borings for monitoring well installation, where no soil samples are collected for chemical analysis, are hollow stem augering and/or drive and wash, based on geologic conditions as determined by the site geologist. The preferred method of drilling test borings for collecting soil samples for visual or chemical analysis is the hollow-stem auger method. The use of drilling fluids will not be allowed for the test borings. The borings shall be advanced in accordance with the drilling specifications developed for this project. All borings not converted to monitoring wells will be backfilled over the entire length with a cement grout. Drill cuttings will be collected and disposed by Allied (see Section 4.2.8).

Borings drilled to collect soil samples will range in depth from 5 to 15 feet, based on topography and depth to the water table, or as determined by the site geologist. Boring depths for monitoring wells will range from approximately 10 to 25 feet, with an estimated average of 17 feet. The actual depth for each well boring will be determined by the site geologist, who will choose the lithologic interval displaying the most favorable aquifer flow characteristics. The depth of the water table will be measured and/or confirmed by the site geologist prior to well completion.

During drilling operations, Standard Penetration Tests and split-barrel sampling will be performed continuously for soil borings where soil samples are collected for visual or chemical analysis (test borings) and at nominal 5-foot intervals for those borings where soil samples are collected solely for lithologic description (monitoring well borings), or as determined by the field geologist. These sampling procedures shall be performed in accordance with ASTM D1586-84 (see Appendix A), modified to obtain sufficient soil for chemical analysis by using a 3-inch outside diameter, split-barrel sampler driven with a 300-pound hammer.

Each soil sample collected for lithologic description will be placed in an 8-ounce jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded (i.e., project, boring and sample numbers, depth, blow counts, and date) by the field geologist. Samples obtained for chemical analysis will be placed in the appropriate laboratory-cleaned containers (supplied by the laboratory). The driller shall prepare a separate written boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities.

A complete log of each well boring will be maintained by NUS in accordance with NUS SOP GH-1.5 (see Appendix A). Appendix B contains an example of the boring description form (log).

At a minimum, the boring log will contain the following information, when applicable, for each overburden well boring:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA/HNU readings (if taken), drilling methods, and total depth of each borehole should be included on each log, as well as any other pertinent observations. Sample bottles containing soil samples for lithologic description will be consecutively numbered starting with S-1. In addition, the following information shall be recorded on the lid of these sample jars:

- Job name and number
- Well number and sample number
- Date
- Depth of sample
- Blow counts

4.2.4 Monitoring Well Construction/Installation

For the Phase I RFI, monitoring well installation is proposed only for Study Area 1. Since LNAPL (cumene) is known to exist in this area, Study Area 1 monitoring wells will be constructed of 2-inch-diameter, flush-joint-threaded, stainless-steel casing and well screens equipped with an end plug. Figure 4-1 illustrates typical well construction details for the monitoring wells.

Well screens will be 10 feet in length. The slot size will be determined in the field, but will be no larger than 0.02 inches. Placement depths of well screens will be determined in the field based on drilling observations and the anticipated groundwater-level fluctuations. The screens will be installed to monitor the top of the water table.

The stainless-steel well installation procedure will consist of backfilling the boring (if required) with a sand/bentonite mix to a depth of approximately 1/2 to 1 foot below the desired depth for the bottom of the well screen. The stainless-steel riser and screen will be placed at the desired depth in the completed boring. The annulus of the boring around the well screen, and 1 to 3 feet above the well screen, will be backfilled with clean silica sand (Nos. 20 to 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal (minimum 2-foot thickness) will then be installed and allowed to hydrate; the remainder of the annulus of the boring (from the seal to ground surface) will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless-steel or plastic tape.

Protective steel casings equipped with locking steel caps will be installed around all wells and piezometers. In addition, a cement apron will be built up around the casing to prevent ponding of water around the well. All locks supplied for the wells will be keyed alike. After installation, the ground surface, the top of the riser pipe, and the top of the protective casing will be surveyed to within 0.01-foot vertical accuracy. In addition, the well will be surveyed to a 0.1-foot horizontal accuracy.

A monitoring well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix B.

4.2.4.1 Well Development

All newly installed monitoring wells will be developed after installation to remove fines and sediments from around the well screens and to remove drill cuttings and residual drilling fluids from

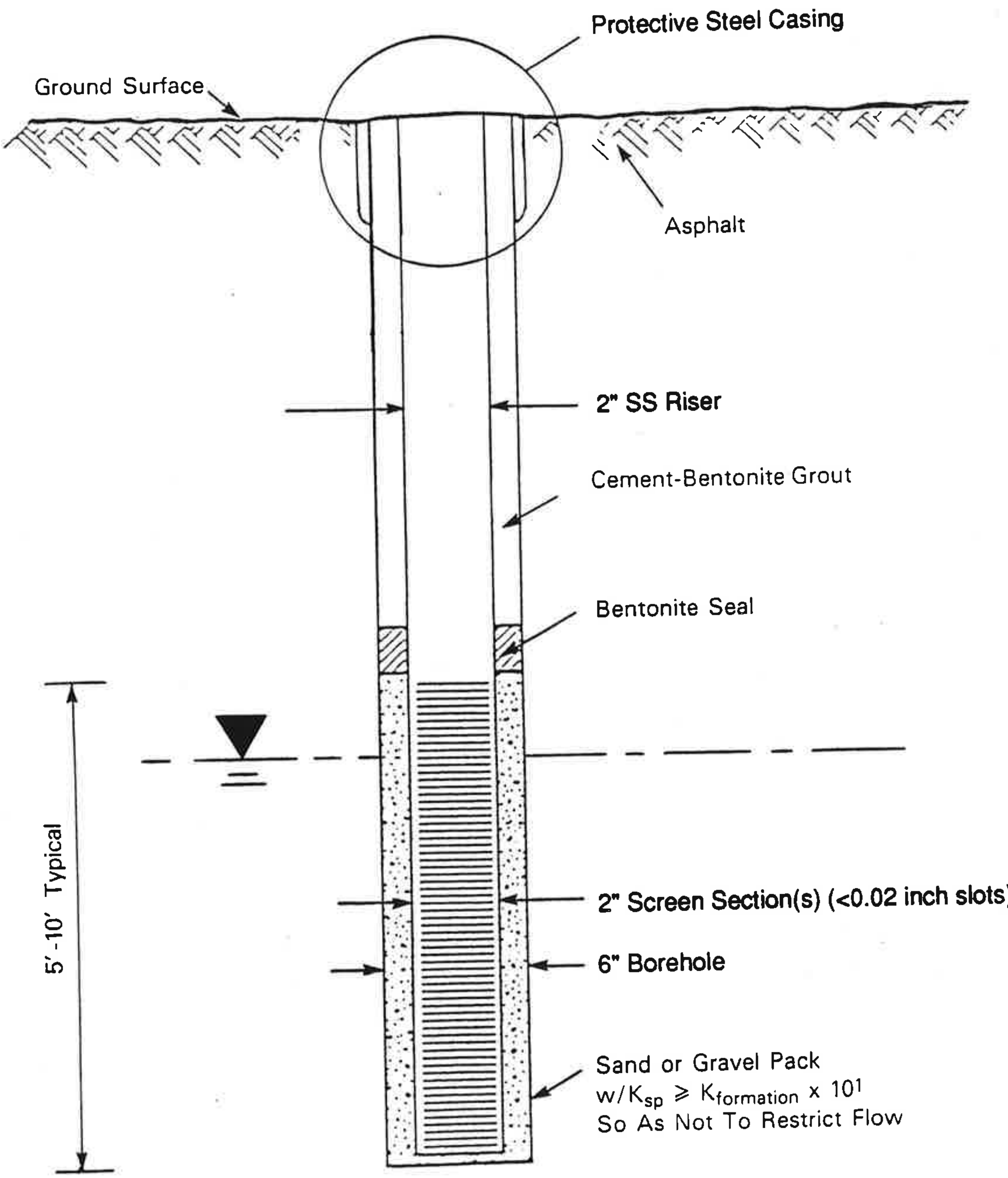


FIGURE 4-1
TYPICAL SHALLOW MONITORING WELL INSTALLATION

ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

NUS CORPORATION
A Halliburton Company

the area around the monitored interval of the boring. If existing usable piezometers are identified during the RFI, they will also be developed, if necessary. Wells will be developed by air lift, bailing and surging, or pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist. Development water will be handled according to procedures outlined in Section 4.2.8.

4.2.4.2 Procedures for Aquifer Testing

Monitoring wells will be used for aquifer testing to determine the groundwater flow conditions in the water-bearing zones investigated by each well. The data generated from these tests will be used to assess the water-yielding characteristics of each formation, develop groundwater velocity values, and estimate the rate of groundwater movement for the aquifers in the vicinity of the monitoring wells that are tested.

In-situ hydraulic conductivity testing (slug tests) will be performed in the newly installed monitoring wells. Procedures for performing these slug tests will be in accordance with Section 5.1 of NUS SOP GH-2.4. Pressure transducers and data loggers will be used for data collection, where appropriate, to obtain sufficiently accurate field data. At a minimum, the following information will be collected (when applicable) for each well during the performance of aquifer tests:

- Well number/depth/screened interval/inside diameter of screen/diameter of sand pack
- Static water level
- Method of inducing water-level change
- Time/recovery data
- Total time of test

Data generated by the tests will be documented on the appropriate data sheets and analyzed according to Section 5.3 of NUS SOP GH-2.4, using the most appropriate evaluation technique for the existing hydrologic conditions. A sample data sheet is provided in Appendix B.

4.2.4.3 Water-Level Monitoring

Groundwater elevations (and flow directions) beneath portions of the Allied facility are expected to vary temporally, because of rising and falling tides in Frankford Inlet and the on-off cycling of the groundwater recovery wells. Because of this expected variation, a 7-day water-level monitoring program has been devised. Data developed from this program will be used to develop overall groundwater flow directions, gradients, flow rates, and velocities.

Simultaneous water-level measurements shall be obtained by installing IN SITU® type, pressure-sensitive transducers in monitoring wells, recovery wells, and one staff gage location in the inlet. All measurements shall be taken in reference to the top of the well or staff gage, that will be later surveyed for vertical control. The transducers shall be connected to a HERMIT SE 2000 or HERMIT SE 1000 B Hydrologic Monitor that will record water-level measurements over time. Transducers shall be installed in a minimum of two recovery (pumping) wells, two monitoring wells, and at one staff gage location. The specific wells to be monitored shall be determined by the field geologist, based on site conditions. The well locations selected for monitoring should meet the following criteria:

- Provide adequate coverage across the property
- Provide water level data at a well location that is near the inlet
- Provide water level data at a well location that is distant from the inlet
- Provide water level data at maximum drawdown pumping wells

The water-level measurements shall be recorded at a minimum of 1-hour intervals over an entire duration of 7 days. In addition, initial water-level measurements shall be collected manually in all the wells located on the property and at the two staff gage locations on the inlet prior to the installation of the transducers, as well as at selected intervals during the 7-day test. Manual measurements will be taken with an M-scope (electrical water-level indicator), steel tape and chalk, or popper, using the top of the riser pipe as the reference point for determining depths to water for the wells and piezometers. Water-level measurements will be recorded to the nearest 0.01 foot in the appropriate field log book. The measuring device will be decontaminated between wells by cleaning the portion of the device that comes into contact with liquid in the monitoring well with deionized water.

Prior to the 7-day measurement, groundwater pumping rates will be determined, using either flow meters (if available) or manual methods. (Pumping durations will be determined during the test by analyzing the transducer data from the recovery wells.) If functioning flow meters are not available, then field measurements shall be taken to collect the data. The measurements shall consist of estimating pumping volume over time with a calibrated container and a stopwatch, or by using other comparable methods as determined to be appropriate by the field geologist.

The resultant transducer data shall be converted to elevations and plotted on hydrographs. Comparison of hydrographs in the wells with the hydrograph of the inlet shall be used to determine the amount of time that groundwater flows toward and discharges into the inlet versus the time that the inlet recharges groundwater. The hydrographs can also be used to evaluate changes in the groundwater flow gradients and their relationship to changes in drawdown of the pumping wells and tidal fluctuations in the inlet.

The manual water-level measurements collected and the water transducer data shall both be converted to elevations. The water-level elevations at a specific time and date shall be plotted on a base map for developing potentiometric surface contours. The potentiometric surface contour maps will be used to determine both groundwater flow directions and gradients.

4.2.5 Staff Gages

Two staff gages will be placed in Frankford Inlet adjacent to the site. One staff gage shall consist of a reference point marked on the bridge leading to the south tank farm. The second gage will be located in the inlet on the Bridge Street bridge near the southeastern corner of the Allied property. The top of the staffs should be at least 1 foot above the known maximum water level. A horizontal black line shall be placed on an orange background near the top of the staff gage, indicating the reference point elevation for measuring the static water level of the surface-water body.

4.2.6 Surveying

Surveying services will include the surveying of horizontal locations and vertical elevations of newly installed monitoring wells, existing piezometers (if any), and staff gages. Vertical elevation shall be surveyed to an accuracy within 0.01 feet and within 0.1 feet for horizontal locations.

The ground elevation, the top of the protective casing, and the top of the uncapped riser pipe of the newly installed monitoring wells and piezometers shall be surveyed with respect to horizontal locations and vertical elevations. Each point of measurement shall be marked using a heavy, black indelible ink marker.

The staff gages will contain an inscribed permanent marking, which will serve as the point of measurement. Thus, the horizontal location and vertical elevation to this point of measurement shall be surveyed for the staff gages.

Soil boring locations will also be surveyed. Horizontal location accuracy shall be within 0.1 foot, whereas vertical elevations (of the ground surface) will be established within 0.01 foot.

4.2.7 Reporting

The following reports and documentation will be the responsibility of the field geologist during the drilling activities. Copies of applicable forms that will be used by the site geologist are located in Appendix B.

Site Logbook - See NUS SOP SA-6.3.
Daily Activities Record-Field Investigation Report - See Appendix B.
Boring Log - See Appendix B.
Overburden Monitoring Well Sheet - See Appendix B.
Data Sheet for Slug Test - See Appendix B.
Groundwater Level Measurement Sheet - See Appendix B.

The field geologist's notebook shall contain information about the drilling activities such as start/finish times, standby times, and problems or changes encountered during excavation. Drilling and monitoring well construction information (e.g., footage drilled, depth of casing, etc.) will be recorded daily on the boring log and the overburden monitoring well sheet, as appropriate. The boring logs, along with the geologist's notebook, will be used to prepare the Daily Activities Record - Field Investigation Report. This report will identify drilling activity and quantities of material used on a daily basis, and shall be signed by the drilling subcontractor foreman (or equivalent) and the site geologist. The reports shall be submitted to the Project Manager at the completion of each week. These reports will also be used to fill out the site logbook.

4.2.8 Investigation Waste Disposal

Drill cuttings will be collected and disposed of by Allied as hazardous or nonhazardous waste, as appropriate. Decontamination water, monitoring well development water, and purge water will be collected for treatment on site using Allied's wastewater collection and pretreatment system.

4.3 GENERAL SAMPLING OPERATIONS

4.3.1 Subsurface Soil Sampling

This soil sampling plan was developed to investigate the subsoil beneath the 12 SWMUs and 2 AOCs. A total of forty-nine borings will be drilled and sampled at various locations throughout these units, as discussed in Section 2.0.

Soil samples will be collected for chemical analysis during the drilling activities using split-spoon samples, as discussed in Section 4.2.2.1. Samples will be collected continuously, or as determined by the site geologist. Procedures for obtaining the soil sample from the split spoon will be in accordance with NUS SOP GH-1.3, Section 5 (Appendix A). All pertinent field data, including soil pH, shall be recorded using Attachment B-8 of NUS SOP SA-6.1 (Sample Log Sheet in Appendix B) and the field notebook.

4.3.2 Groundwater Sampling

One round of groundwater sampling will be conducted for the three newly installed monitoring wells. The proposed analytes for the groundwater samples are specified in Table 3-1.

Groundwater samples will be collected in accordance with NUS SOP SA-1.1, Section 5. Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated stainless-steel bailer or a suction pump. Three to five well volumes will be purged. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 70 percent; then a sample will be collected. In the event that recovery is slow, samples will be collected the following day. Field measurements, including pH, Eh, dissolved oxygen, temperature, and specific conductance, will be taken at the beginning, middle, and end of purging, according to SF-1.1 (Section 5.0). Filtered samples will be obtained for metals analysis. Filtering and preservation of samples shall be conducted in accordance with SF-1.2 (Section 5.2.5).

Dedicated stainless-steel bailers will be used for sample collection. With the exception of the metals, samples will be poured directly from the bailer into the appropriate sample bottles for analysis.

All pertinent field data shall be recorded using Attachment B-7 of SA-6.4 (Sample Log Sheet in Appendix B) and the field notebook.

4.4 SAMPLE ANALYSIS

Samples collected at the Allied facility will be submitted for the laboratory analyses presented in Table 3-1. This table indicates the analytical parameters and analytical methods for each sample. Table 4-1 summarizes the analyses, bottle requirements, preservation requirements, and holding times for each sample.

4.5 DECONTAMINATION PROCEDURES

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. Such equipment includes drilling rigs, downhole tools, augers, pumps, well casing and screens, soil and water sampling equipment, and water-level measurement devices.

4.5.1 Major Equipment Decontamination

All drilling equipment, including the drill rig and its transport system, shall be steam-cleaned as follows: prior to beginning work, between the drilling of separate boreholes, any time the drilling rig leaves the drill site prior to completing a boring, and at the conclusion of the drilling program.

Decontamination operations will consist of washing equipment using a high-pressure steam wash. All decontamination activities will take place on the existing Allied facility tanker truck wash apron. Additional requirements for drilling equipment decontamination can be found in NUS SOP GH-1.6, Section 5.

4.5.2 Sampling Equipment Decontamination

All sampling equipment used for collecting samples for chemical analysis shall be decontaminated both prior to sampling in the field and between samples in accordance with Section 5 of NUS SOP SF-2.3. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Methanol rinse
- Distilled/deionized water rinse
- Air dry

Field analytical equipment, such as instrument probes, will be rinsed with distilled/deionized water.

4.5.3 Personnel Decontamination

Personnel decontamination is discussed in the Health and Safety Plan (Section 2.0 of Volume 3 of this RFI Plan).

5.0 LABORATORY SAMPLE CUSTODY

The NUS Pittsburgh, Pennsylvania laboratory will provide analytical services for the Allied Fibers RFI. NUS' Pittsburgh laboratory is EPA- and Pennsylvania-certified (PA #02-089). Copies of the laboratory's Quality Assurance Plan are available upon request.

To ensure the integrity of the sample from collection through analysis, it is necessary to have an accurate, written record that traces the possession and handling of the sample. This documentation of the history of the sample is referred to as chain-of-custody. The components of chain-of-custody (chain-of-custody seals, field notebook, chain-of-custody record, sample bottle labels, and laboratory sample tracking forms) and procedures for their use are described in this section.

For the purpose of this discussion, "custody" is defined as follows:

- The sample is in the physical possession of an authorized person, or
- The sample is in the view of an authorized person after being in his/her possession, or
- The sample is secured by an authorized person so it cannot be tampered with (or tampering will be evident if it does occur) after being in his/her possession, or
- The sample is in a secured area, restricted to authorized personnel.

Sample custody during collection and shipping was discussed in the previous section. Laboratory chain-of-custody is discussed in the remainder of this section.

5.1 SAMPLE RECEIPT

When samples are routinely received at the laboratory, a sample log-in clerk signs and dates the shipping manifest to acknowledge receipt of the shipment. He/she then examines the shipping containers and verifies that the correct number of shipping containers was received by signing the air bill. He/she opens the shipping containers to remove the enclosed sample documents and record the cooler temperature. If temperature excursions are noted, the project manager will be contacted to address the need for corrective action.

Following this, he/she removes the samples from the shipping container and records the condition of the sample bottles (intact, broken, cracked, leaking, etc.) on the sample log-in sheet. He/she then crosschecks the information on the chain-of-custody records, the air bill, the sample containers, and the list of anticipated samples to determine whether there are discrepancies in the information. Both agreement and discrepancies are recorded on the sample log-in sheet. When discrepancies are found in any of the information, the sample log-in clerk notes them on the sample log-in sheet and a noncomformance/corrective action record. Following this, the sample log-in clerk signs and dates the sample log-in sheet when all the information is recorded and has been crosschecked.

The sample log-in clerk next physically applies a laboratory sample number to each bottle. He/she signs the chain-of-custody record in the box labeled "Received for Laboratory By." If problems are noted with the shipment, the sample log-in clerk documents the nature of the problem in the "Remarks" box of the chain-of-custody record. Since direct laboratory tracking of sample custody is to be maintained, the sample log-in clerk completes the top portion of a lab tracking record.

The laboratory project manager reviews all log-in information, including document nonconformances at sample receipt and analyses assigned. If discrepancies are noted, the laboratory project manager will contact the RFI project manager to address the discrepancies. The laboratory project manager signs and dates the log-in records when everything is complete and properly assigned.

5.2 SAMPLE STORAGE

Storage conditions and retention times are defined below for each type of sample.

- Samples for base/neutral acid extractable organic analyses are protected from light and refrigerated from the time of receipt until analysis is completed.

- Samples for volatile organics analysis are protected from light and refrigerated, separate from all other samples, from time of receipt until analysis.

- Samples for total organic carbon (TOC) are refrigerated from the time of receipt until analysis is completed.

- Samples for metals are stored from the time of receipt until analysis is completed.

- Samples maintained under laboratory chain-of-custody will be kept in locked storage areas. Samples maintained under laboratory chain-of-custody will be kept in locked storage until receipt of a validation report; extracts are also kept in locked storage until receipt of a validation report.

- The laboratory will ship the samples or sample extracts to the client in sufficient time to ensure that they reach the shipping point within seven (7) days of notification.

- After the holding time requirement for samples has elapsed, samples, extracts, and containers will be returned to Allied for disposal.

5.3 LABORATORY SAMPLE TRACKING

Laboratory sample tracking is discussed in some detail in the NUS Laboratory Quality Assurance Plan (Section QA-7). (This plan is available upon request.) Each sample will be tracked on a lab tracking record.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

Instruments used in the field and in the laboratory will be calibrated according to the procedures described below.

6.1 FIELD INSTRUMENTS

Several monitoring instruments may be used during field activities, including

- Temperature probe
- Specific conductance meter
- pH meter
- Eh meter
- Electronic water-level meter
- Dissolved oxygen meter

The electronic water-level meter will be calibrated prior to mobilization and periodically at the discretion of the FOL. The remaining instruments will be calibrated daily or according to the manufacturer's operating manual.

Calibration will be documented on an Equipment Calibration Log (NUS SOP SA-6.4, Appendix B). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

6.2 LABORATORY INSTRUMENTS

The quality control procedures routinely employed in laboratory analyses are presented in Section 9.0 of this document.

7.0 ANALYTICAL PROCEDURES

Solid and aqueous samples will be collected for chemical analyses. The analytical procedures to be used are summarized in Table 7-1. Method references are included as footnotes. The anticipated turnaround time for receiving analytical results is 40 days.

TABLE 7-1

ANALYTICAL METHODS FOR CHEMICAL PARAMETERS
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

Analytical Parameter	Solid Matrix Analytical Method and Preparation Method	Aqueous Matrix Analytical Method and Preparation Method
Volatile Organics	CLP SOW 3/90	CLP SOW 3/90
BNA Extractables	CLP SOW 3/90	CLP SOW 3/90
Metals	-	CLP SOW 3/90
Pesticides and PCBs	-	CLP SOW 3/90
Herbicides	-	SW 8150
Organophosphorus Pesticides	-	SW 8140
Dioxin Screen	-	SW 8270
TOC	SW 9060	SW 9060

SW - EPA, 1986c. "Test Methods for Evaluating Solid Wastes - Physical/Chemical Methods," 3rd Edition.

CLP SOW - USEPA Contract Laboratory Program Statement of Work

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation, and reporting will be conducted as described below.

8.1 DATA REDUCTION

The calculation of final results from raw data varies from parameter to parameter with the calibration approach. The ratio of instrument response to analyte concentration is determined for one or more standards. In general, if the concentration/instrument response ratio is linear, the average of the ratios is used to calculate sample results. If the response is not linear, response is plotted against concentration, and sample results are quantitated from the resultant curve.

Results are generally expressed to two significant figures. Results for aqueous samples are expressed in µg/l. Organic results for solid samples are expressed in µg/kg, whereas inorganic results are expressed in mg/kg.

8.2 DATA VALIDATION AND REPORTING

The results of quality control checks are the primary tools used for data validation. Quality control checks are described in Section 9.0. Acceptance criteria (control limits) are discussed in Section 3.0. Raw data and final results are reviewed by the laboratory group leader on a daily basis. The group leader confirms that documentation is complete and legible; qualitative identifications are accurate; calculations are accurate; results are expressed in the appropriate units and number of significant figures; and the required quality control checks were run and met acceptance criteria. Review and approval of the data is documented by the group leader.

The tabulated chemical-analytical data generated by the laboratory will be sent to the sampling coordinator, who will log it into the validation tracking system. The data will be validated by the NUS Chemistry and Toxicology Department. Validation of the chemical-analytical data will include a quality assurance assessment to determine whether specified protocols were followed by the laboratory personnel. Results for field blanks and duplicates will be reviewed for consistency (i.e., relative percent difference values) and to identify laboratory artifacts. The laboratory will provide reagent blank, surrogate spike, and matrix spike results. This information will also be reviewed through comparison with the specified control limits (see Section 3.0). All validation will be performed using the latest EPA Functional Guidelines as a reference. Documentation of the validity of laboratory results will be provided to the NUS Project Manager and to Allied Fibers in the form of letter reports.

Chemical-analytical data generated during the study will be reduced to a concise form for presentation in the final RFI report. The analytical results will be managed using an existing computer program developed by NUS specifically for chemical data bases. This program is capable of handling a large number of chemicals, and will be customized for the Allied Frankford RFI to accommodate all indicator parameters. Quality assurance procedures will be implemented to assure that no errors occur during data entry. The data entered into the program are checked by the computer operator, and the printouts are checked against the original laboratory sheets by a chemist.

9.0 INTERNAL QUALITY CONTROL CHECKS

Quality control checks to be implemented in the field and in the laboratory are described below.

9.1 FIELD QUALITY CONTROL CHECKS

In addition to periodic calibration of field equipment and appropriate documentation, quality control samples will be collected or generated during environmental sampling activities. Quality control samples include field duplicates and blanks. Each type of field quality control sample is defined as follows:

Equipment (Rinsate) Blanks - Equipment blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment (bailer, split spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of nondedicated sampling equipment used and will be submitted at a frequency of one per every twenty samples or one per sampling trip if less than twenty samples are collected.

Field (Sample Matrix) Blanks - are composed of analyte-free which are transported to the field and exposed to the same conditions as field samples. Field blanks are a tool for assessing contamination from the total sampling, sample preparation, and measurement process. Field blanks will be submitted at a frequency of one per every twenty samples, or one per sampling trip if less than twenty samples are collected.

Trip Blanks - allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. Trip blanks will be submitted for volatile organic compound analysis only, at a frequency of one per sample shipment (batch).

Field Duplicates - Field duplicates are samples that are divided into two portions at the time of sampling. Field duplication provides precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis. Field duplicates will be submitted at a frequency of one per every twenty samples, or one per sampling trip if less than twenty samples are collected.

The proposed field quality control samples are included in Table 3-1 (Section 3.0).

(Note: Allied reserves the right to collect quality control samples at a frequency greater than indicated in this plan.)

9.2 LABORATORY QUALITY CONTROL CHECKS

Laboratory analyses will be conducted in accordance with the appropriate analytical methods (see Table 7-1). Internal laboratory quality control checks may include surrogate and matrix spike addition and analysis as well as reagent blank generation and analysis. Analysis will be performed in accordance with the NUS laboratory's standard operating procedures.

9.2.1 Volatile Organics

The quality control procedures routinely employed in gas chromatography/mass spectrophotometry (GC/MS) analyses of water and soil/sediment for VOAs are presented below and are summarized in Table 9-1.

Mass Spectrometer Calibration and Instrument and Column Performance Evaluation

The mass assignment and resolution of the mass spectrometer is calibrated at the start of each analytical run and every 12.0 hours of operation using bromofluorobenzene (BFB). The ion abundance criteria specified in the method must be met before any analyses are attempted. If difficulty is encountered in meeting the criteria for BFB, the mass spectrometer is tuned and re-evaluated until the requirements for BFB are met. For continuing calibration of CLP Target Compound List (TCL) compounds, a mid-point standard is run at the start of each run and every twelve hours of operation thereafter.

Internal Standardization

The GC/MS is calibrated initially with five standards covering the working range of the instrument. The initial calibration will be used to demonstrate the linear range and estimate the reporting limit. Minimum relative response factors (RRFs) and percent difference of the initial average and continuing calibration RRFs must be met prior to proceeding with analysis.

Surrogate Standards

Surrogate standards, which are deuterated or halogenated compounds, are added to all samples and blanks during sample preparation. The recoveries of the surrogate compounds are used to isolate any

TABLE 9-1

CALIBRATION AND QUALITY CONTROL REQUIREMENTS
ALLIED FIBERS FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

	BFB-DFTPP Tune	IC	Continuing Calibration	Verification Standard	Internal Standard	Method Blank	Surrogate Standard(s)	MS/MSD	Matrix Spike	Matrix Duplicate
VOAs by GC/MS	HD	I	HD		S	E	S	1/20		
BNA Extractables by GC/MS	HD	I	HD		S	E	S	1/20		
Herbicides By GC		I	D			E	S	1/10		
Organophosphorus Pesticides by GC		I	D			E	(2)	1/10		
Pesticides/PCBs by GC/ECD		I	F			E	S	1/10		
Metals by Flame AA		E	T	E		E	(2)		1/10	1/10
Metals by Graphite Furnace AA		E	T	E		E	(2)		1/10	1/10
Mercury		E	T	E		E	(2)		1/10	1/10
TOC		I	D	D					1/20 D	1/20 D

(1) A blank is analyzed daily or with each set of samples, but it is used to zero the analytical system.
(2) A lab control standard is analyzed with each batch.

HD	Every twelve hours of operation.
D	Each day samples are run.
E	Each set of samples prepared, by matrix.
I	Initially, and whenever continuing calibration criteria are not met.
IC	Initial calibration
MS/MSD	Matrix spike/matrix spike duplicate.
S	Each standard, blank, and sample.
1/10	One in ten samples analyzed, by matrix.
1/20	One in twenty samples analyzed, by matrix.
F	Every five samples.
T	Every ten samples.

Internal Standardization

The GC/MS is calibrated initially with five standards covering the working range of the instrument. The initial calibration will be used to demonstrate the linear range and estimate the reporting limit. Minimum relative response factors (RRFs) and percent difference of the initial average and continuing calibration RRFs must be met prior to proceeding with analysis.

Surrogate Standards

Surrogate standards, which are deuterated or halogenated compounds, are added to all samples and blanks during sample preparation. Their recoveries of the surrogate compounds are used to isolate any problems that could occur throughout the entire analytical process. For example, for base-neutral and acid analysis, a preliminary extraction is required prior to analysis. The surrogates are added prior to the extraction so that not only instrument problems, but also extraction problems and sample matrix problems, can be detected. Six surrogates are used for BNA analyses. The acceptance criteria for the recoveries of the surrogate compounds are presented in Table 3-2.

Blanks

Method blanks are analyzed with each batch of samples. Blanks will be analyzed on each instrument used to analyze samples. One liter of deionized water is extracted and analyzed to check for glassware and reagent contamination. Should sample analysis indicate possible contamination, the analysis of blanks is used to isolate the source of the problem.

Matrix Spike Duplicates

At a frequency of one sample in 20 samples of similar matrix, matrix spike analysis is performed in duplicate for BNA extractables. Matrix spikes are prepared by adding a known amount of standard to actual samples. The acceptance criteria for evaluating precision and spike recoveries are presented in Table 3-2.

9.2.3 Herbicides

The quality control procedures routinely employed in chlorinated herbicide analyses of water and soil/sediment are presented below. They are also summarized in Table 9-1.

Standardization/Calibration

The external standardization method is used to calibrate the gas chromatograph. The GC is calibrated initially with three calibration standards covering the working range of the instrument. A one-point calibration is performed daily, at a minimum, for all compounds of interest. The standard peak areas are calculated, and sample peak areas are compared to that of the standard.

Surrogate Standards

Surrogate spiking compounds are added to samples, blanks, and standards for analysis of herbicides. As is done when base-neutral and acid analyses are performed, the surrogate is added before extraction to point out extraction problems and sample matrix interferences. The acceptance criteria for the recovery of the surrogates are calculated in accordance with Section 8.3 of Method 8150.

Blanks

A deionized water blank is prepared each day that samples are extracted. Blanks will be analyzed on each instrument used to analyze samples.

Matrix Spike Duplicates

At a frequency of one sample in ten samples of similar matrix, matrix spike analysis is performed in duplicate for herbicides. Matrix spikes are prepared by adding a known amount of standard to actual samples.

9.2.4 <u>Organophosphorus Pesticides</u>

The quality control procedures routinely employed in organophosphorus pesticide analyses of water and soil/sediment are presented in the following text. They are also summarized in Table 9-1.

Standardization/Calibration

The external standardization method is used to calibrate the gas chromatograph. The GC is calibrated initially with three calibration standards covering the working range of the instrument. A one-point calibration is performed daily, at a minimum, for all compounds of interest. The standard peak areas are calculated, and sample peak areas are compared to that of the standard.

Laboratory Control Standards

A laboratory control standard containing all target compounds will be prepared and analyzed with each batch. If acceptance criteria are not met, sample results must be verified through reanalysis.

Blanks

A deionized water blank is prepared each day that samples are extracted. Blanks will be analyzed on each instrument used to analyze samples.

Matrix Spike Duplicates

At a frequency of one sample in ten samples of similar matrix, matrix spike analysis is performed in duplicate for organophosphorus pesticides. Matrix spikes are prepared by adding a known amount of standard to actual samples.

9.2.5 Pesticides/PCBs

The quality control procedures routinely employed in pesticide/PCB analyses of water and soil/sediment are presented below. They are also summarized in Table 9-1.

Calibration

The initial and continuing calibration protocol defined in the EPA Contract Laboratory Program Statement of Work is followed with two exceptions: (1) analysis may extend beyond 72 hours as long as continuing calibration criteria are met, and (2) when breakdown exceeds 20%, only samples containing Endrin, DDT, or their decomposition products must be reanalyzed. Analysis may not proceed until breakdown is corrected, however.

Surrogate Standards

A surrogate spiking compound, dibutylchlorendate, is added to samples, blanks, and standards for analysis of pesticides/PCBs. As is done when base-neutral and acid analyses are performed, the surrogate is added before extraction to point out extraction problems and sample matrix interferences.

Blanks

A deionized water blank is prepared each day that samples are extracted. Blanks will be analyzed on each instrument used to analyze samples.

Matrix Spike Duplicates

At a frequency of one in ten samples of similar matrix, matrix spikes for pesticides/PCBs are performed in duplicate. (A pesticide standard mixture is used as the spike for both pesticides and PCBs when both sets of compounds are to be determined.) The acceptance criteria for evaluating precision and spike recoveries are presented in Table 3-2.

9.2.6 Metals

The quality control procedures routinely employed in inorganic chemistry analyses are presented below. They are also summarized in Table 9-1.

Standardization

For flame and graphite furnace atomic absorption units, the instrument will be calibrated at the start of each run according to manufacturer's instructions using a blank, a mid-range standard, and an upper-range standard, at a minimum. Immediately thereafter, the blank, the mid-range and upper-range standard, and an additional standard within the linear range will be rerun. All standards must read 95.0-105% of their true value. If not, the instrument will be recalibrated. Also a reporting limit standard will be run to verify instrument sensitivity. This standard must be detected before proceeding with analysis.

For inductively coupled plasma (ICP) units, the instrument will be calibrated (profiled) at the start of each run according to the manufacturer's instructions. Prior to sample analysis, the highest calibration standard will be rerun. Recovery must be 95.0 to 105%. If it is not, the instrument will be recalibrated.

For cold vapor mercury units, a minimum of a blank and four standards will be run. If the relative standard deviation (RSD) of the response factors are $\leq 7.5\%$, quantitation will be done from the mean response factor. Otherwise, a curve will be drawn. Minimum sensitivity criteria for the highest standard must be established for each unit and met.

The initital calibration will be verified by running an initial calibration verification (ICV) standard immediately after initial calibration. The ICV must be independent of the calibration standards. Recovery of this standard must be 90.0 - 110% (80.0 - 120% for Mercury). If acceptance criteria are not met, the analytical system will be troubleshot and an acceptable ICV standard recovery will be obtained before proceeding with analysis.

A continuing calibration (CC) standard will be run after each set of ten samples and at the end of the run. Recovery of the standard must be 90.0 - 100% (85.0 - 115% for graphite furnace analyses, 80.0 - 120% for mercury). If acceptance criteria are not met, all samples analyzed since the last acceptable ICV or CC standard must be rerun.

A CC blank will also be run after each CC standard. If a baseline shift exceeding ± the absolute value of the reporting limit is noted, the baseline will be reset and all samples run since the last acceptable CC blank will be rerun.

Method Blanks

A method blank will be analyzed with each batch of up to 20 samples of similar matrix (water or soil/sediment/waste). Blanks will be analyzed on each instrument used to analyze samples. The level of each analyte in the blank must be less than the reporting limit (not to exceed the negative value of the reporting limit). If acceptance criteria are not met, all samples that contain the analyte at levels from the reporting limit to ten times the amount of analyte in the blank will be reanalyzed.

Laboratory Control Standard

A laboratory control standard (LCS) will be analyzed with each batch of up to 20 samples of similar matrix. If percent recovery acceptance limits are not met for an analyte, the associated samples must be reanalyzed. However, if it can be shown that an LCS is outside of acceptance limits because of deterioration of the spiking standard or some other defect that would affect only the LCS, all samples associated with the LCS need not be reanalyzed.

Duplicates

One in ten samples analyzed for a specific parameter is run in duplicate each day. Differing aliquots are used in many instances to conserve sample and to test for matrix interferences.

Matrix Spikes

One in ten samples analyzed for a specific parameter is spiked with the analyte each day, for those parameters for which a stable standard is available. An aliquot of standard solution is added to the sample.

9.2.7 TOC

The quality control procedures for total organic carbon (TOC) analysis are summarized in Table 9-1.

10.0 PERFORMANCE AND SYSTEM AUDITS

Audits to be conducted in the field and in the laboratory are described below.

10.1 FIELD AUDITS

A QA performance audit will be performed by the NUS Quality Assurance Officer (QAO) during the RFI. The audit will include checks on adherence to all applicable Standard Operating Procedures and checklists described in Section 4.0.

The auditor shall prepare audit checklists or audit guides. The depth and scope of the audit shall be determined and incorporated into the checklist or guidelines. The audit will cover the following items:

- Adherence to sample collection SOPs
- Chain-of-custody
- Documentation of field activities as per SOPs
- Equipment maintenance and calibration
- Training requirements for site workers
- Documentation of variances from field activities and corrective actions

Where an audit team is involved, the audit team leader shall establish the ground rules for the audit and assign to the various team members the specific areas each is to cover in the audit.

The above audit checklist/guide shall be used to guide the audit and to ensure adequate depth, scope, and continuity. However, the auditor shall not restrict the audit when evidence raises questions not specifically addressed in the checklists. The audit activity shall include the review of objective evidence to verify adequate implementation of the quality assurance program.

The auditor shall record each finding of nonconformance to project specifications and/or requirements (observation or deficiency) on a Quality Notice Form. When a finding is identified, sufficient investigation shall be conducted to determine the basic cause of the finding. Findings shall be written only when there is a clear noncompliance with a specific Standard Operating Procedure or specification.

Any identified findings that require immediate corrective action shall be reported immediately to the Project Manager and recorded on a Quality Notice Form.

Corrective action is addressed in Section 13.0. Distribution of quality assurance reports is addressed in Section 14.0.

10.2 LABORATORY AUDITS

The laboratory conducting the analyses is fully certified and approved. Quality assurance/quality control procedures are in use. An internal audit schedule will be available, as well as a record of audits by certification agencies. The results of all audits and the corrective action process will be available.

11.0 PREVENTIVE MAINTENANCE

Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance shall be controlled by established procedures as described in Section 4.0. Measuring and test equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards, according to the procedures for the methods. Equipment will be calibrated periodically. Test equipment used for calibration of sensors shall also be calibrated at least once a year or when maintenance or damage indicates a need for recalibration.

NUS maintains a large inventory of sampling and measurement equipment. In the event that failed equipment cannot be repaired, replacement equipment can be shipped to the site by overnight express carrier to minimize downtime.

12.0 DATA ASSESSMENT FOR PRECISION, ACCURACY, AND COMPLETENESS

The procedures used to assess precision, accuracy, and completeness (PAC) of laboratory data are described in Section 3.0. Upon completion of the analytical phases of the project, data will be reviewed and validated as outlined in Section 8.0. In conjunction with the data review and validation, the specific PAC results will be compared with the laboratory quality control criteria and the completeness objective. Discrepancies may affect the usefulness of the data. The Project Manager will decide whether any additional sampling and analysis is required.

13.0 CORRECTIVE ACTION

The need for corrective actions may become apparent during surveillance of field activities, procurement of services and supplies, or other operations that may affect the quality of work. Deficiencies and nonconformances will be promptly identified by the Quarterly Assurance Officer's (QAO's) quality assurance checks in the audit reports outlined in this Sampling and Analysis Plan. Corrective action will be taken immediately by the Project Manager and/or field personnel.

The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective actions shall be documented by the QAO and reported to the appropriate levels of management. The NUS Project Manager will have overall responsibility for implementing corrective actions, and must identify those responsible for initiating corrective action to remedy immediate effects of the problem.

The corrective action program covers the analysis of the cause of any negative audit findings and the corrective actions required. This program includes the investigation of the cause of significant or repetitious unsatisfactory conditions relating to the quality of sampling, service, or the failure to implement or adhere to required quality assurance practices such as SOPs.

Acceptability of laboratory data is defined by the PARCC parameters in Section 3.0 of this Sampling and Analysis Plan. If the data do not meet these criteria, it may be necessary to resample the locations for which deficiencies were noted. The NUS Pittsburgh laboratory has audit and corrective action procedures in place that it must follow.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Quality Assurance Officer (QAO) shall prepare a report summarizing the quality assurance and quality control status for the project and any conditions adverse to quality. Topics to be included in the report are as follows:

- Results of any audits.
- Results of surveillances.
- Any nonconformances initiated.
- Training provided to project personnel.
- Any significant quality assurance problems, together with recommended solutions.

The QAO will compile the reports into a composite report for the Project Manager.

Assessment of the measurement data for precision, accuracy, and completeness is performed by the Chemistry/Toxicology Group and is reported to the Project Manager and Allied Fibers in the form of data validation letters.

It is tentatively planned that one field audit will be conducted during the RFI.

REFERENCES

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49 Federal Register 43260.

APPENDIX A

STANDARD OPERATING PROCEDURES FOR FIELD ACTIVITIES

ALLIED SIGNAL, INC.
FIBERS DIVISION, FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

APPENDIX A

STANDARD OPERATING PROCEDURES FOR FIELD ACTIVITIES

GH-1.2: Evaluation of Existing Wells

GH-1.3, Section 5: Soil and Rock Sampling

GH-1.4, Section 5: Soil and Rock Drilling Methods

GH-1.5, Section 5: Borehole and Sample Logging

GH-1.6, Section 5: Decontamination of Drilling Rigs and Sample Equipment

GH-2.4, Section 5: In-Situ Hydraulic Conductivity Testing

SA-1.1, Section 5: Groundwater Sample Aquisition

SA-6.1, Section 5: Sample Identification and Chain-of-Custody

SA-6.2: Sample Packaging and Shipping

SA-6.3: Site Logbook

SA-6.4, Section 5: Forms Used in RI Activities

SF-1.1, Section 5: On-Site Water Quality Testing

SF-1.2, Section 5: Sample Preservation

SF-2.3, Decontamination of Chemical Sampling and Field Analytical Equipment

ASTM D1586-84, Section 7: Penetration Test and Split-Barrel Sampling of Soils

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.2	Page 1 of 4
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject EVALUATION OF EXISTING MONITORING WELLS		Approved D. Senovich	

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SECTION

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating existing monitoring wells, and to insure that the validity of data to be collected from these wells is usable during site investigations.

2.0 SCOPE

This procedure is applicable during stages of a site investigation. The procedures are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

The program represents a comprehensive approach to evaluating existing monitoring wells. Because of its comprehensiveness, completion of the program as specified will result in some duplication of effort. The actual level of evaluation program will depend on the data that are available (or which can be made available), the use to which that data will be put (i.e., the data quality objectives), and the effect that data will have on the time, budget and data quality for the overall program.

3.0 GLOSSARY

Data Quality Objectives (DQO) - qualitative and quantitative statements specifying data quality (i.e. measurement of uncertainty) required to support the objectives of the groundwater monitoring program.

4.0 RESPONSIBILITIES

Site Geologist - responsible for overseeing field inspections and for assessing the structural integrity of the wells and related field conditions. The geologist will carry out well evaluation procedures and assess the physical condition of the wells. These results and conclusions concerning the conditions of existing monitoring wells should be discussed with the Site Manager and Field Operation Leader, who together, will then determine which of the existing monitoring wells can be utilized.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology;
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths;
- Satisfactory methods of groundwater sampling and analysis to meet the data quality objectives (DQOs);
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 PRELIMINARY EVALUATION

A necessary first step in evaluating existing monitoring well data will be the study and review of the original work plan for monitoring well installation (if available). This will help to familiarize the geologist with specific site conditions requiring analysis, will promote an understanding of the original purpose of the monitoring wells and will help to determine if the well installation can meet the current DQOs. For example, existing wells may be sufficient for RCRA compliance but not for contaminant plume identification. Of particular interest during this phase of the project will be the rationale for the horizontal location of the wells and the vertical position and length of the monitored interval.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology and will help to establish consistency between hydraulic properties of the well to physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates the distance from prominent site features, or the location of the well on a map;
- The installation dates, drilling methods, well development methods, and contractors;
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-spoon sampling) may be used to estimate bedrock interface;
- The soil profile and stratigraphy;
- The borehole depth and diameter;
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface;
- The total depth of the well;
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval;
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size;

5.2 FIELD INSPECTION

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock;
- The condition of the cement seal surrounding the protective casing;
- The presence of depressions or standing water around the casing;
- The presence of any electrical cable and its connections.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results since the time when leakage started is unknown.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, the steps described above should be taken to rehabilitate the well. After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a PID or FID meter and combustible gas meter to determine the appropriate worker safety level. The following information should be noted:

- Cap function;
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing;
- Presence of a riser cap, method of attachment to casing, and venting of the riser;
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.
- The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. Specific field investigative activities which should be carried out include:
- This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present, the well be should be redeveloped before sampling.
- As a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

6.0 RECORDS

A record of all field procedures, tests and observations should be recorded in a field log book. Entries in the log book should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 <u>Equipment</u>

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

6.0 REFERENCES

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7.0 RECORDS

None.

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SECTION

1.0 PURPOSE

The purpose of this procedure is to describe the methods, the sequence of operations and the equipment necessary to perform soil and rock borings.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallo drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

6.0 REFERENCES

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7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

ing nent	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
w-Stem	6 1/4	5	2 1/4	-
ers	6 3/4	5 3/4	2 3/4	-
f 7)	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	
Wall	-	2	1 7/8	-
Samplers	-	2 1/2	2 3/8	-
f 7)	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
	-	5	4 3/4	-
. Rods	RW	1 3/32	23/32	13/32
7)	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (in)
en External	2 1/2	2.875	2.323	0.276
led Extra	3	3.5	2.9	0.300
ng Steel*	3 1/2	4.0	3.364	0.318
ng (Ref 8)	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

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		Applicability EMG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) aré cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an álternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG **NUS CORPORATION**

PROJECT: .... BORING NO.: ....
PROJECT NO.: .... DATE: .... DRILLER: ....
ELEVATION: .... FIELD GEOLOGIST: ....
WATER LEVEL DATA: ....
(Date, Time & Conditions) ....

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,Ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS

REMARKS ____________________

BORING ______

PAGE ____ OF ____

033490

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)> ¼" Ø	CLEAN GRAVELS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel sand mixtures, little or no fines.
	GRAVELS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures.
SANDS 50%(+)< ¼" Ø	CLEAN SANDS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

FINE GRAINED SOILS

More than half of material is SMALLER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)				GROUP SYMBOL	TYPICAL NAMES
Identification procedures on fraction smaller than No. 40 sieve size					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

- S - 2" O.D. Split Barrel Sample
- ST - 3" O.D. Undisturbed Sample
- O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

- X - NX (Conventional) Core (~2 1/8" O.D.)
- Q - NQ (Wireline) Core (~1 7/8" O.D.)
- Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▼ 12.6' Initial Level w/Date & Depth

12/18
▼ 12.6' Stabilized Level w/Date & Depth

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3′	Massive
30 cm - 1 meter	1.0′ - 3.3′	Thick Bedded
10 cm - 30 cm	4″ - 1.0′	Medium Bedded
3 cm - 10 cm	1″ - 4″	Thin Bedded
1 cm - 3 cm	2/5″ - 1″	Very Thin Bedded
3 mm - 1 cm	1/8″ - 2/5″	Laminated
1 mm - 3 mm	1/32″ - 1/8″	Thinly Laminated
<1 mm	< 1/32″	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE — BORING NO: MW 3A
PROJECT NO: 619Y — DATE: 9-21-87 — DRILLER: B. GOLLHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 -TPVC 10-16-87

SAMPLE NO & TYPE/ RQD	DEPTH (ft) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/ft) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS & ROCK BROKENNESS	REMARKS
S-1	0.0	3 / 6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST OPPM
	1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11 / 100/.5	0.8/1.0	5.5 / 6.0	M. SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP OPPM
					TO				REFUSAL @ 6' 5.5 TOP OF DEC ROCK
					M. HARD				
									AUGERED TO 15' W/SOLID STEM AUG
									CUTTING MOIST @ ≈8' WATER @ 11'±
									WL @ 12:10 PM WAS ≈ 9' FROM GS.
									SET 4" PVC CAS. @ 15.0'
9-21 / 9-22	15.0								
					M. HARD	BRN GRAY	SILTY SHALE - FEW	VBR	SEVERAL Fe STAINED JOINTS ON CORE 0 PPM
							QUARTZ PCS		THRUOUT RUN.
									JOINTS AND BREAKS ARE HORIZ TO LO ∠.
									W/ VUGS ON LOWER PORTION 23 TO 25 OF CORE
0.5/10.0	①	05/5	7.9/10.0						
	25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2" Φ SP. SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A

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BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE
BORING NO.: MW 3A
PROJECT NO.: 619Y
DATE: 9-22-87
DRILLER: B. GOLLIHUE
ELEVATION:
FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

9-22

SAMPLE NO & TYPE RQD	DEPTH (FT) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO 4 JNTS
							(SILTSTONE)		≈26 TO 27 2- VERT
							- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
							SEAMS	·	ROCK BECOMES AND BREAKS MORE LIKE
									A SILTSTONE WITH DEPTH.
0/10.0	②	0%	8.7/10.0						
								BR	≈32 TO 33 FEW QUARTZ PIECES W/
								VBR	VUGS. SL. MICACEOUS
									VF QUARTZ GRAINS IN MATRIX - 30X MAG.
	35.0								≈34 TO 35 · 2 VERT JOINTS
					M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
							- FEW QUARTZ	BR	
							SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
									LAMINATIONS. WATER STAINED JNTS
								BR	THRUOUT RUN MORE SO 35-37±
1.0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
									42.7 → 43.0 HI ∠ JNT
								BR	42.4 → 42.7 VERT JNT
								VBR	
	45.0								45.3 → 45.5 VERT JNT. & VBR
									47.5 VERT JOINT
								BR	48. HI ∠ JOINT
									SLIGHTLY CALCAREOUS MORE CALCITE
									PRESENT

REMARKS

BORING MW 3A

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* See Legend on Back

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO & TYPE	DEPTH (Ft.)	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION*: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION*: COLOR	MATERIAL DESCRIPTION*: MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	5	0%	1.8/10.0						
	65.0								
				66					
									65.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	6	0%	1.3/10.0						POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS: AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE. AT 1:50 pm CORED HOLE TO 75' REAMED TWICE DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED 2ND TIME TO 81'. SET WELL 66'-76'.

BORING: MW3A

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* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE
PROJECT NO: 473 Y
DATE: 7-7-87
ELEVATION: 1462.37
FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): 5.54' @ 8:50 AM 7-23-87 T-PVC
BORING NO: MW 013
DRILLER: B ERICSON
PENN - DRILL
ACKER AD-II

SAMPLE NO & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft.) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU) (HEAD SP)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR. COAL FRAG		3/4" Ø FRAG - NEAR OLD RR. LINE.
							TR-CC FRAG		
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO	SANDY SILT - TR [illegible] TO	SM	MOIST TO WET (0PPM)
	6.5	3				GRAY	SILTY SAND - TR GRAVEL		GRAY SAND @ 6' ± INCL'EOUS LOOSE MATERIAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS (GRAV)		1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/.4	.9/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4¼" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON
FORD 8000 TRUCK
SAMPLES TAKEN
USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG

NUS CORPORATION

PROJECT: WESTLINE SITE
PROJECT NO.: 473Y
DATE: 7-7-87
BORING NO.: MW013
DRILLER: S ERICSON
ELEVATION:
FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.) OR SCREEN INT.	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-6	25.0 / 26.5	6 / 17 / 30	1.1/1.5		DENSE	OLIVE BLUE GRAY	SILTY SAND - SOME GRAVEL - TR CLAY TR. SS FRAG	GM	WET 0PPM. S.S. IS FRIABLE FIRST CHANGE IN COLOR. NOT ENOUGH CLAY TO BE CONFINING NOTE: MAY SET ZONE 2 CASING ≈ 28'
	30.0					MOTTLED			
S-7	31.5	17 / 27 / 36	1.4/1.5		V. DENSE	BRN BLUE GRAY	SILTY SAND - SOME GRAVEL [illegible] TR CLAY	GM/GM	MOIST → WET (0PPM) [illegible] GRAY & FRIABLE. [illegible] NOT MUCH CLAY - BUT MAY BE SEMI-CONFINING.
	35.0								
S-8	35.9	30 / 50/.4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND - SOME GRAVEL TR. SS FRAG	SM/GM	MOIST → WET (0PPM) V. SL. TR CLAY - LESS THAN S-7 1" Ø FRAG - MORE COARSE SAND THAN ABOVE. POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED HOLDS TOGETHER WHEN
	40.0					BLUE			
S-9	41.5	31 / 34 / 24	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.) SOME GRAVEL - TR CLAY	SM/GM	MOIST → WET (0PPM) LITTLE MORE CLAY THAN S-8 SUBROUNDED GRAVEL VERY SLOW DRILLING 40-45 (RIG STALLS) LESS CLAY LAST 3" OF SAMPLE
	45.0					BLUE			
S-10	46.5	13 / 34 / 50	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.) SOME GRAVEL - TR CLAY	SM/GM	MOIST → WET (0PPM) 1" Ø SIZE - HOLDS TOGETHER WHEN SQUEEZED BUT NOT COHESIVE CLASSIFICATION [illegible] DRILLING TO 50'

7/7
7/8

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 @

BORING MW013

PAGE 2 OF 4

D334901

NUS CORPORATION

ENVIRONMENTAL MANAGEMENT GROUP

STANDARD OPERATING PROCEDURES

Number: GH-1.6	Page: 1 of 3
Effective Date: 05/04/90	Revision: 2
Applicability: EMG	
Prepared: Earth Sciences	
Approved: D. Senovich	

Subject: DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

TABLE OF CONTENTS

SECTION

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-2.4	Page 1 of 7
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject IN-SITU HYDRAULIC CONDUCTIVITY TESTING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly describe

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies required and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system, which might raise doubts regarding the representativeness of future groundwater samples. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape, coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 DATA ANALYSIS

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) may be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A*. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

* If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
HYDRUALIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — ***NUS CORPORATION***

PROJECT NAME: .... WELL/BORING NO.: ....
PROJECT NO.: .... GEOLOGIST: ....
WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....
STATIC WATER LEVEL (Depth/Elevation): ..../............ DATE: ....
TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....
METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

vac 1/88

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 14
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		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- <u>Sample packaging and shipping equipment</u> - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- <u>Field tools and instrumentation</u> - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- <u>Pumps</u>

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Working schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.
6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.
7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.
8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.
9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer)

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

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7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
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SAMPLE LOG SHEET

- ☐ Monitoring Well Data
- ☐ Domestic Well Data
- ☐ Other ______

Page ____ of ____

Case # ________

By ________

Project Site Name ____________________ Project Site Number ____________

NUS Source No. ____________________ Source Location ____________

	Purge Data				
Total Well Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Well Casing Size & Depth:					
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.)					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

	Sample Data			
Sample Date & Time:	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):

Observations / Notes:

Type of Sample

- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch								
Water level <25 ft		x	x	x	x			
Water level >25 ft				x				
2-Inch								
Water level <25 ft	x	x	x	x	x	x		
Water level >25 ft	x			x		x		
4-Inch								
Water level <25 ft	x	x	x	x	x	x	x	x
Water level >25 ft	x			x		x	x	x
6-Inch								
Water level <25 ft				x	x		x	x
Water level >25 ft				x			x	x
8-Inch								
Water level <25 ft				x	x		x	x
Water level >25 ft				x			x	x

Manufacturer	Model name/number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc	BarCad Sampler	dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors available; must be primed
Galtek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1076 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive displacement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable; helical rotor (positive displacement)	1.75/26	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter - Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thickness of "floating" contaminants
Q E D Environmental Systems, Inc	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas, piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co	Model 500 Vari Flow Pump	portable, peristaltic (suction)	<0 5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0 30	see comments	1200 1300	flow rate dependent on motor and tubing selected, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton® acrylic, PE	0-500	0-1800 mL/min	2600 2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20 60	other sizes, materials, models available; optional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0 150	350 mL/flushing cycle	100 200	requires compressed gas; other sizes, materials, models available; no solvents used
Tole Devices Co	Sampling Pump	portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials Abbreviations

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
SS	Stainless Steel
PC	Polycarbonate
EPDM	Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA	Not Applicable
AC	Alternating Current
DC	Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

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		Applicability: EMG	
		Prepared: Earth Sciences	
Subject: SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved: D. Senovich	

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1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration**: The expected concentration (i.e., low, medium, high).
- **Sample Type**: Grab or composite.
- **Preservation**: Type of preservation added and pH levels.
- **Analysis**: VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By**: Printed name of the sampler.
- **Case Number**: Case number assigned by the Sample Management Office.
- **Traffic Report Number**: Number obtained from the traffic report labels.
- **Remarks**: Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a w[illegible]e, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w[illegible] or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and i[illegible]ovided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la[illegible]atory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code**: Work Assignment Number.
- **Station Number**: The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year**: Same as Date on Sample Label.
- **Time**: Same as Time on Sample Label.
- **Designate - Comp/Grab**: Composite or grab sample.
- **Station Location**: Same as Station Location on Sample Label.
- **Samplers**: Same as Sampled By on Sample Label.
- **Preservative**: Yes or No.
- **Analyses**: Check appropriate box(es).

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME					NO. OF CON-TAINERS							REMARKS
SAMPLERS: (Signature)													
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION								

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: ______

STATION LOCATION: ______

DATE: ___/___/___ TIME: ______ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ ______ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	______ ☐
______ ☐	

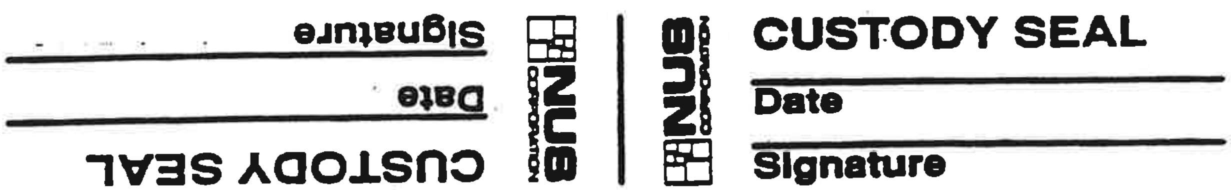
Sampled by: ______

Case No.: ______ Traffic Report No.: ______

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL



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		Prepared Earth Sciences	
Subject SAMPLE PACKAGING AND SHIPPING		Approved D. Senovich	

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Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	[illegible]	CONTAINER NUMBERS	PIC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-[illegible]	C	1	✓	
1	55 gal	450 lbs.	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-[illegible]	—	2		✓
1	55 gal	250 lbs.	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-[illegible]	B	3	✓	
1	16-A	12 lbs.	x	Bromine	Corrosive Material	55-[illegible]	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd ______

Shipment Date ______ Manifest No ______

Disposer Work Order ______

Service Order No ______

NUS CORPORATION

ENVIRONMENTAL MANAGEMENT GROUP

STANDARD OPERATING PROCEDURES

Number SA-6.3	
Effective Date 05/04/90	Revision 2
Applicability EMG	
Prepared Earth Sciences	
Approved D. Senovich	

Subject SITE LOGBOOK

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SECTION

1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ____________ DATE: ____________

SITE LEADER: ____________________
PERSONNEL:

NUS	DRILLER	EPA

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well _______ resumes. Rig geologist was ____________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ________.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well ________.

4. Well ________ drilled. Rig geologist was ____________________. See Geologist's Notebook, No. 2, page ______ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well ________ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit ________.

8. Test pit ________ dug with cuttings placed in dump truck. Rig geologist was ____________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

____
Field Operations Leader

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Subject FORMS USED IN RI ACTIVITIES		Approved D. Senovich	

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1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of.

3.0 GLOSSARY

<u>Controlled Document</u> - A consecutively-numbered form released by EPA for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

4.0 RESPONSIBILITIES

<u>Field Operations Leader</u> - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test forms (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 Sample Label

The sample label is a 2- by 4-inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1.

5.1.2 Sample Identification Tag

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

5.1.3 Chain-of-Custody Record Form

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in Zone 1 uses a slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. Chain-of-custody record forms for Regions I, II, and IV are illustrated in SA-6.1 as well as procedures for filling out forms.

5.1.4 Chain-of-Custody Seal

Attachment B-4 is an example of a custody seal. The Custody seal is a 1- by 3-inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

5.1.5 Bottle Delivery Order (DO) Form

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

5.1.6 Repository Packing List (PL) Form

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

5.1.8 Sample Log Sheet

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

5.1.10 Traffic Report Label

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.

5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations
Attachment B-1 - Sample Label
Attachment B-2 - Sample Identification Tag
Attachment B-3 - Chain-of-Custody Record From, ~~Region III~~
Attachment B-4 - Chain-of-Custody Seal
~~Attachment B-5 - CLP Sample Bottle Repository Order Form~~
~~Attachment B-6 - Repository Packing List Form~~
Attachment B-7 - Groundwater Sample Log Sheet Form
Attachment B-8 - Soil Sample Log Sheet Form
~~Attachment B-9 - Surface Water Sample Log Sheet Form~~
~~Attachment B-10 - Container Sample Log Sheet Form~~
~~Attachment B-11 - Organics Traffic Report Form~~
~~Attachment B-12 - Inorganics Traffic Report Form~~
~~Attachment B-13 - Traffic Report Labels~~
~~Attachment B-14 - Special Analytical Services (SAS) Packing List~~
~~Attachment B-15 - Dioxin Shipment Record Form~~
~~Attachment B-16 - Sample Shipping Log~~
Attachment C-1 - Groundwater Level Measurement Sheet
~~Attachment C-2 - Pumping Test Data Sheet~~
Attachment C-3 - Hydraulic Conductivity Testing Data Sheet
~~Attachment C-4 - Packer Testing Report Form~~
Attachment C-5 - Summary Log of Boring
Attachment C-6 - Overburden Monitoring Well Construction Sheet
~~Attachment C-7 - Confining Layer Monitoring Well Construction Sheet~~
~~Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet~~
~~Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet~~
~~Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet~~
~~Attachment C-11 - Test Pit Log Form~~
Attachment D-1 - Equipment Calibration Log

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP Number	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
~~B-5~~	~~CLP Sample Bottle Repository Form~~	~~SA-6.6~~	~~Required~~
~~B-6~~	~~Repository Packing List Form~~	~~SA-6.6~~	~~Required~~
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
~~B-9~~	~~Surface Water Sample Log Sheet~~	~~SA-6.6~~	~~Required~~
~~B-10~~	~~Container Sample Log Sheet~~	~~SA-6.6~~	~~Required~~
~~B-11~~	~~Organics Traffic Report Form~~	~~SA-6.6~~	~~Controlled~~
~~B-12~~	~~Inorganics Traffic Report Form~~	~~SA-6.6~~	~~Controlled~~
~~B-13~~	~~Traffic Report Labels~~	~~SA-6.6~~	~~Controlled~~
~~B-14~~	~~Special Analytical Services (SAS) Packing List~~	~~SA-6.6~~	~~Required~~
~~B-15~~	~~Dioxin Shipment Record Form~~	~~SA-6.6~~	~~Required~~
~~B-16~~	~~Sample Shipping Log~~	~~SA-6.4~~	~~Required~~
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
~~C-2~~	~~Pumping Test Data Sheet~~	~~GH-2.3~~	~~Required~~
C-3	Hydaulic Conductivity Testing Data Sheet	GH-2.4	Required
~~C-4~~	~~Packer Testing Report Form~~	~~GH-2.2~~	~~Required~~
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
~~C-7~~	~~Confining Layer Monitoring Well Construction Sheet~~	~~GH-1.5~~	~~Required~~
~~C-8~~	~~Bedrock (Open Hole) Monitoring Well Construction Sheet~~	~~GH-1.5~~	~~Required~~
~~C-9~~	~~Bedrock (Well Installed) Monitoring Well Construction Sheet~~	~~GH-1.5~~	~~Required~~
~~C-10~~	~~Bedrock (Well Installed) Monitoring Well Construction Sheet~~	~~GH-1.5~~	~~Required~~
~~C-11~~	~~Test Pit Log~~	~~GH-1.8~~	~~Required~~
D-1	Equipment Calibration Log	----	Required

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Subject ONSITE WATER QUALITY TESTING		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements

2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 GLOSSARY

3.1 pH MEASUREMENT

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

) GUIDELINES

1 MEASUREMENT OF pH

1.1 General

easurement of pH is one of the most important and frequently used tests in water chemistry. actically every phase of water supply and wastewater treatment such as acid-base neutralization, ater softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be rrelated with other chemical analyses to determine the probable source of contamination. It is erefore important that reasonably accurate pH measurements be taken.

easurements of pH can also be used to check the quality and corrosivity of soil and solid waste mples. However, these samples must be immersed in water prior to analysis, and specific chniques are not described.

vo methods are given for pH measurement: the pH meter and pH indicator paper. The indicator iper is used when only a rough estimate of the pH is required, and the pH meter when a more curate measurement is needed. The response of a pH meter can be affected to a slight degree by gh levels of colloidal or suspended solids, but the effect is usually small and generally of little gnificance. Consequently, specific methods to overcome this interference are not described. The sponse of pH paper is unaffected by solution interferences from color, turbidity, colloidal or spended materials unless extremely high levels capable of coating or masking the paper are countered. In such cases, use of a pH meter is recommended.

1.2 Principles of Equipment Operation

se of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of e solution with the indicator compound on the paper. Depending on the indicator and the pH nge of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, r both. Process chemistry and molecular transformations leading to the color change are variable nd complex.

se of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on stablishment of a potential difference across a glass or other type of membrane in response to ydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, combination with a standard or reference electrode, a potential difference proportional to ydrogen ion concentration can be generated and measured.

1.3 Equipment

ne following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

Temperature (°C)	Specific Conductance (μmhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

1 Data derived from the International Critical Tables 1-3-8.

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008

ATTACHMENT B
VARIATION OF DISSOLVED OXYGEN CONCENTRATION
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY
PAGE TWO

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concenration (and therefore used to correct measured D.O. concentration) using Attachment A.

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Subject SAMPLE PRESERVATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4 - Sulfuric Acid
HNO_3 - Nitric Acid
$NaOH$ - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. EPA-EMSL, Cincinnati, Ohio.

7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

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ATTACHMENT A
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	Extractables				
	Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	**Metals**				
	Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	Cyanide				
	Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H_2SO_4 to pH <2	28 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 l	H_2SO_4 to pH <2	28 days
Phenols	--	h.d. polyethylene	1.0 l	H_2SO_4 to pH <2	28 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
SOIL					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	Extractables				
	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
Air					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIRMENTS CERCLA/RCRA SAMPLES

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 1

Parameter No./Name	Container(1)	Preservation(2,3)	Maximum Holding Time(4)
INORGANIC TESTS:			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid(5)	14 days(6)
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
METALS:(7)			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO_3 to pH 2	6 months

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 2

Parameter No./Name	Container(1)	Preservation(2,3)	Maximum Holding Time(4)
ORGANIC TESTS:(8)			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5) HCl to pH 2(9)	14 days
Acrolein and Acrylonitrite	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5) adjust pH to 4-5(10)	14 days
Phenols(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
Benzidines(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction(13)
Phthalate Esters(11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines(11,14)	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
PCBs(11) Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark	7 days until extraction, 40 days after extraction
Haloethers(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons(11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
PESTICIDES TESTS:			
Pesticides(11)	G, Teflon-lined cap	Cool, 4°C, pH 5-9(15)	7 days until extraction, 40 days after extraction
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the ice of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at ·° until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation zardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the .ic types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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		Applicability EMG	
		Prepared Earth Sciences	
Subject	DECONTAMINATION OF CHEMICAL SAMPLING AND FIELD ANALYTICAL EQUIPMENT	Approved D. Senovich	

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1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse .
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid factions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

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* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

** If sampling for pesticides, PCBs, or fuels.

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2 FIELD ANALYTICAL EQUIPMENT

5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.

Standard Method for

PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 – 58 T. Last previous edition D 1586 – 67 (1974).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "N-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb

(63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job.

8.1.2 Names of crew.

8.1.3 Type and make of drilling machine.

8.1.4 Weather conditions.

8.1.5 Date and time of start and finish of boring.

8.1.6 Boring number and location (station and coordinates, if available and applicable).

8.1.7 Surface elevation, if available.

8.1.8 Method of advancing and cleaning the boring.

8.1.9 Method of keeping boring open.

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made.

8.1.11 Location of strata changes.

8.1.12 Size of casing, depth of cased portion of boring.

8.1.13 Equipment and method of driving sampler.

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners).

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number.

8.2.2 Description of soil.

8.2.3 Strata changes within sample.

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

~~9. Precision and Bias~~

~~9.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.~~

~~9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values~~

APPENDIX B

FORMS FOR FIELD ACTIVITIES

ALLIED SIGNAL, INC.
FIBERS DIVISION, FRANKFORD PLANT
PHILADELPHIA, PENNSYLVANIA

APPENDIX B-- FORMS FOR RI ACTIVITIES

Attachment A	-	Daily Activities Record-Field Investigation Form
Attachment B-1	-	Sample Label
Attachment B-3	-	Chain-of-Custody Record Form, Region III
Attachment B-4	-	Chain-of Custody Seal
Attachment B-7	-	Groundwater Sample Log Sheet Form
Attachment B-8	-	Soil Sample Log Sheet Form
Attachment C-1	-	Groundwater Level Measurement Sheet
Attachment C-3	-	Hydraulic Conductivity Testing Data Sheet
Attachment C-5	-	Summary Log of Boring
Attachment C-6	-	Overburden Monitoring Well Construction Sheet
Attachment D-1	-	Equipment Calibration Log
QAPP Figure 7-2	-	Task Modification Request Form

ATTACHMENT A

DAILY ACTIVITIES RECORD - FIELD INVESTIGATION ***NUS CORPORATION***

PROJECT NAME: ____________________ PROJECT NO.: ____________

CLIENT: ____________________ LOCATION: ____________________

DATE: ____________________ ARRIVAL TIME: ____________ DEPARTURE TIME: ____________

CONTRACTOR: ____________________ DRILLER: ____________________

BORING NO.: ____________ NUS REPRESENTATIVE: ____________________

ITEM (1)	ORIGINAL QUANTITY (2) ESTIMATE	QUANTITY (2) TODAY	PREVIOUS TOTAL (2) QUANTITY	CUMULATIVE QUANTITY (2) TO DATE
1. Mobilization/Demobilization	Job			
2. Overburden Drilling/Sampling, minimum 6-inch	100 ft.			
3. Overburden Drilling, 10-inch	250 ft.			
4. Overburden Drilling 14-inch	450 ft.			
5. Bedrock Drilling 6-inch	530 ft.			
6. Bedrock Drilling 10-inch	650 ft.			
7. Bedrock Drilling 14-inch	150 ft.			
8. Temporary 6-inch Steel Casing	250 ft.			
9. Temporary 10-inch Steel Casing	200 ft.			
10. Temporary 14-inch Steel Casing	250 ft.			
11. Permanent 6-incn Steel Casing	1,250 ft.			
12. Permanent 10-inch Steel Casing	400 ft.			
13. PVC Well Construction/Installation	1,120 ft.			
14. Mine Void Sealing	8			
15. Boring Backfilling	NA			
16. Well Development	24 hrs.			
17. Test Borings	200 ft.			
18. Test Pit Excavation	50 hrs.			
19. Standby	20 hrs.			

COMMENTS: ____

(1) AS LISTED IN SPECS
(2) INCLUDE QUANTITY AND UNITS
(Ex. 20 ft., 6 hrs.)

APPROVED BY:

____
NUS FIELD REPRESENTATIVE

____
DRILLER OR REPRESENTATIVE

ATTACHMENT B-1

SAMPLE LABEL

NUS CORPORATION PROJECT: ____________________

STATION LOCATION: ____________________

DATE: ___/___/___ TIME: __________ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ __________ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	__________ ☐
__________ ☐	

Sampled by: ____________________

Case No.: __________ Traffic Report No.: __________

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT B-3

CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

CHAIN OF CUSTODY RECORD

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

PROJ NO.	PROJECT NAME					
SAMPLERS: (Signature)					NO. OF CON-TAINERS	REMARKS
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

3-15966

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

Signature ____________________

Date ____________________

CUSTODY SEAL

NUB CORPORATION

NUB CORPORATION

CUSTODY SEAL

Date ____________________

Signature ____________________

ATTACHMENT B-7

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ____________

Page _____ of _____

Case # ____________

By ____________

Project Site Name ____________________ Project Site Number ____________

NUS Source No. ____________________ Source Location ____________

	Purge Data				
Total Well Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Well Casing Size & Depth:					
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

	Sample Data			
Sample Date & Time:	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):	Observations / Notes:

Type of Sample

☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B-8

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other ____________

Page _____ of _____

Case # ____________

By ____________

Project Site Name ____________________ Project Site Number ____________

NUS Source No. ____________________ Source Location ____________

Sample Method:	Composite Sample Data		
	Sample	Time	Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			

Type of Sample

- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Sample Data

Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)

Analysis:

Observations / Notes

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT C-1

GROUNDWATER LEVEL MEASUREMENT SHEET

LOCATION

Project Name: ______________________
Project No.: ______________________
Personnel: ______________________
Date: ______________________

Municipality: ______________________
County: ______________________
State: ______________________
Street or Map Location (If Off-Site) ______________________

WEATHER CONDITIONS

Temperature Range: ______________
Precipitation: ______________
Barometric Pressure: ______________

Equipment No.: ______________
Equipment Name: ______________
Latest Calibration Date: ______________

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT C-3

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — **NUS CORPORATION**

PROJECT NAME: .... WELL/BORING NO.: ....
PROJECT NO.: .... GEOLOGIST: ....
WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....
STATIC WATER LEVEL (Depth/Elevation): ..../.................... DATE: ....
TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....
METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

[illegible] 3/88

ATTACHMENT C-5

BORING LOG *NUS CORPORATION*

PROJECT: .... BORING NO.: ....

PROJECT NO.: .... DATE: .... DRILLER: ....

ELEVATION: .... FIELD GEOLOGIST: ....

WATER LEVEL DATA: ....

(Date, Time & Conditions) ....

SAMPLE NO. & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENESS	REMARKS

REMARKS ____

____

____

BORING ________

PAGE ____ OF ____

ATTACHMENT C-5 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+) > 1/4" Ø	CLEAN GRAVELS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel sand mixtures, little or no fines
	GRAVELS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures.
SANDS 50%(+) < 1/4" Ø	CLEAN SANDS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

FINE GRAINED SOILS

More than half of material is SMALLER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights) — Identification procedures on fraction smaller than No. 40 sieve size	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X - NX (Conventional) Core (~2 1/8" O.D.)
Q - NQ (Wireline) Core (~1 7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
12.6' Initial Level w/Date & Depth

12/18
12.6' Stabilized Level w/Date & Depth

ATTACHMENT C-6

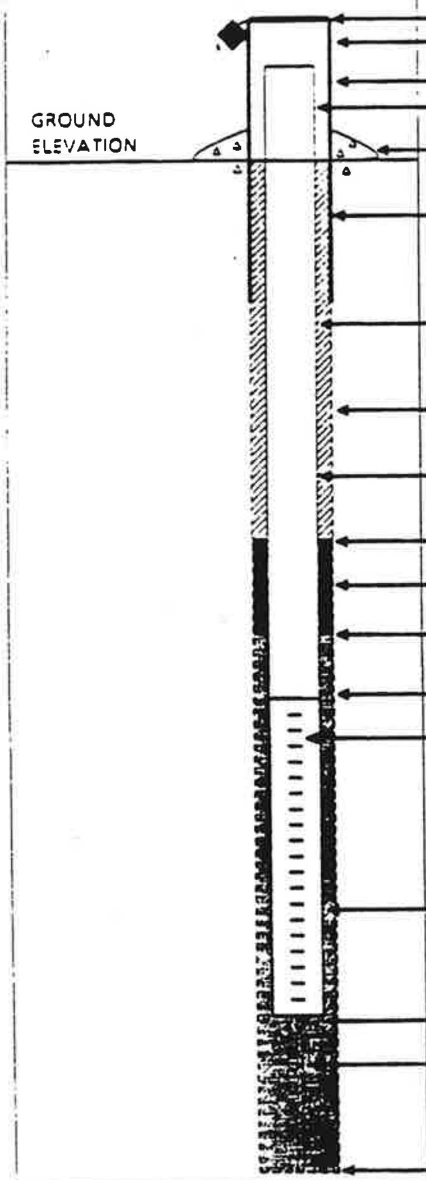
NUS CORPORATION
A Halliburton Company

BORING NO __________

OVERBURDEN
MONITORING WELL SHEET

PROJECT __________ LOCATION __________
PROJECT NO. __________ BORING __________
ELEVATION __________ DATE __________
FIELD GEOLOGIST __________

DRILLER __________
DRILLING METHOD __________
DEVELOPMENT METHOD __________



ELEVATION OF TOP OF SURFACE CASING __________
ELEVATION OF TOP OF RISER PIPE: __________
STICK - UP TOP OF SURFACE CASING: __________
STICK - UP RISER PIPE : __________
TYPE OF SURFACE SEAL: __________
I.D. OF SURFACE CASING: __________
TYPE OF SURFACE CASING: __________
RISER PIPE I.D. __________
TYPE OF RISER PIPE: __________
BOREHOLE DIAMETER: __________
TYPE OF BACKFILL: __________
ELEVATION / DEPTH TOP OF SEAL: __________
TYPE OF SEAL: __________
DEPTH TOP OF SAND PACK: __________
ELEVATION / DEPTH TOP OF SCREEN: __________
TYPE OF SCREEN: __________
SLOT SIZE x LENGTH: __________
I.D. OF SCREEN: __________
TYPE OF SAND PACK: __________
ELEVATION / DEPTH BOTTOM OF SCREEN: __________
ELEVATION / DEPTH BOTTOM OF SAND PACK: __________
TYPE OF BACKFILL BELOW OBSERVATION WELL: __________
ELEVATION / DEPTH OF HOLE: __________

ATTACHMENT D-1

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): ______________________

Manufacturer ______________________ Date Purchased ____________

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

FIGURE 7-2

NUS CORPORATION

[redacted]

TASK MODIFICATION REQUEST

EPA Work Assignment Number ________ Project Number ________ TMR Number ________

To ________ Location ________ Date ________

Description:

Reason for Change:

Recommended Disposition:

Field Operations Leader (Signature) ________ Date ________

Disposition:

Project Manager ________ Date ________

Distribution: Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader

Others as required ________